Course Outcomes and Program Outcomes

3.1. The correlation between the Course and the Program Outcomes(POs)& Program Specific Outcomes(25)

The course outcomes and CO-PO Mapping for few of the courses are given below

Syllabus and Their Course Outcomes (One from each semester)

3ANU1: MECHANICS OF SOLIDS

B.TECH (Aeronautical) 3rd semester

(3L+0T)

3ANU1	CONTENTS	HOURS
	Introduction: Concept of stress, axial loading normal stress, shearing stress, bearing stress, stress on an oblique plane under axial loading; Concept of strain, normal strain under axial loading; Stress-strain diagrams; Hooke's law for 2D and 3D cases; Modulus of elasticity, Poisson's ratio, bulk modulus, modulus of rigidity, shearing strain; Thermal stresses. **Transformation of Stress and Strain:** Principal stresses, maximum shearing stress; Mohr's circle for stress and strain; Stresses in thick and thin-walled pressure vessels. **Stresses in Beams:** Shear force and bending moment diagrams for simply supported and cantilever beams with concentrated, uniformly distributed and variable loads; Theory of pure bending; Bending stress variation in cross-section; Transverse shear stress and its distribution in different sections; Composite beam. **Deflection of Beams:** Deflection in simply supported beams and cantilever with concentrated loads, uniformly distributed loads and their combination. **Columns:** Buckling of columns, differential equation approach, energy approach, approximate techniques; Euler's formula for pin-ended columns and its extension to columns with other end conditions; Concept of equivalent length; Eccentric loading; Rankine formula and other empirical relations. **Torsion:** Deformation in a circular shaft, angle of twist; Stresses due to torsion; Torsion in composite shafts; Saint-Venant's theorem. **TOTAL**	**40**

	TEXT BOOKS	Year
1	"Advanced Engineering Mathematics", R.K. Jain &S.R.K. Iyengar, Narosa Publications	2008
2	"Advanced Engineering Mathematics", O'Neil, Cengage Learning India	2011
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Advanced Engineering Mathematics", E. Kreyszig, Wiley	2010
2.	"Advanced Engineering Mathematics", M. Greenberg, Pearson Education	2013
3.	"Advanced Engineering Mathematics", D.G.Zill& W.S. Wright, Jones & Bartlett India Private Limited	2012
4.	"Higher Engineering Mathematics", B.V. Ramana, McGraw Hill Education	2017

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU1	**MECHANICS OF SOLIDS**	**C01**	Explain the fundamental concept of stress and strain, and the relationship between both in order to solve problems on principle of superposition, compound bars and thermal Stresses.
		C02	Apply the theory of simple bending to seek solution related to the pure and non-uniform bending of beams.
		C03	Analyze the members/structure subjected to combined loading and identify the principal planes/stress/strain.
		C04	Evaluate the torsional stress for various cases of shaft and determine buckling load for column of different end conditions.
		C05	Apply different methods to evaluate deflection of beam and carry out stress analysis of thin pressure vessels.

CO-PO MAPPING

ADVANCED ENGINEERING MATHEMATICS-1	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	3	2		1										
	C02	3	2		1										
	C03	3	3	1	2										
	C04	3	3	1	1										
	C05	3	3	1	2										
	Average	**3**	**2.6**	**1**	**1.4**										

3ANU2: FLUID MECHANICS

B.TECH (Aeronautical) 3rd semester

(3L+0T)

3ANU2	CONTENTS	HOURS
	Fluid Properties: Concept of fluid and flow, ideal and real fluids, continuum concept; Pressure, density, specific gravity, viscosity, compressibility, specific heats, capillarity and surface tension; Newtonian and non-Newtonian fluids. **Fluid Statics**: Pascal's law; Hydrostatic equation; Principle of barometer and manometer; Buoyancy. **Fluid Kinematics**: Eulerian and Lagrangian description of fluid flow; System and control volume concept; Stream, streak and path line, equation of streamline, different types of flows; Conservation of mass in a control volume; Differential equation of continuity; Acceleration, rotation and strain rate of a fluid particle. **Fluid Dynamics**: Linear and angular momentum conservation equation in integral form; Euler's equation; Bernoulli's equation; Conservation of energy; Flow measuring devices – orifice meter, venturimeter, pitot tube. **Viscous Flow:** Navier-Stokes equation, unidirectional flow between stationary and moving parallel plates, flow through pipes, Hagen-Poiseuille law; Reynolds number and its significance. **Introduction to Turbulent Flows**: Reynolds experiment, laminar to turbulent transition; Reynolds decomposition; Shear stress in turbulent flow, eddy viscosity; Prandtl's mixing length hypothesis. **Boundary Layer**: Boundary layer concept; Displacement, momentum and energy thickness; Laminar and turbulent boundary layer flows; Boundary layer separation and control, streamlined and bluff bodies, lift and drag on cylinder and airfoil. **Dimensional Analysis**: Fundamental and derived units and dimensions; Dimensional homogeneity; Dimensional analysis using Rayleigh method & Buckingham-Π theorem; Significance of dimensionless group, use of dimensionless groups in experimental investigation; Geometric, kinematic and dynamic similarity, model testing; Derivations and applications of important dimensionless numbers. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Fluid Mechanics", F.M. White, McGraw Hill Publishing Company Ltd.	1991

2	"Fluid Mechanics: Fundamentals and Applications", Y.A. Cengel & J.M. Cimbala, McGraw Hill Education	2006
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Mechanics of Fluids", I.H. Shames, McGraw Hill Publishing Company Ltd.	1993
2.	"Fluid Mechanics", P.K. Kundu and I.M. Cohen, Academic Press	2011
3.	"Fluid Mechanics", J. F. Douglas, Pearson education	2005
4.	"Introduction to Fluid Mechanics", J.A. Fay, MIT Press	2017

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU2	**FLUID MECHANICS**	**C01**	Apply the basic equation of fluid statics to determine forces on planar and curved surfaces that are submerged in a static fluid.
		C02	Apply conservation laws to determine velocities, pressures, and accelerations for incompressible and inviscid fluids.
		C03	Apply principles of dimensional analysis to identify non dimensional parameters.
		C04	Explain the concepts of viscous boundary layers.
		C05	Apply principles of impacts of jets in fluid machineries.
		CO6	Measure coefficient of discharge of fluid flows.

CO-PO MAPPING

FLUID MECHANICS	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	3	2									3			
	C02	3	2		3						2				
	C03	3	2									3		2	
	C04		2									3		2	
	C05	3	2									3	2		
	CO6	3			3	1								3	
	Average	**3**	**2**		**3**	**1**					**2**	**3**	**2**	**2.33**	

3ANU3: INTRODUCTION TO AERONAUTICS

B.TECH (Aeronautical) 3rd semester

(3L+0T)

3ANU3	CONTENTS	HOURS
	History of Aviation: Brief history of flight vehicle development with emphasis on key ideas, Indian aerospace activities; Aerospace applications. **Aircraft Configurations:** Classification of aircraft and space vehicles; Functions of major components of airplane; Different types of flight vehicles; V/STOL configurations;Basic flight instruments. **Standard Atmosphere:** Physical properties and structure of atmosphere; Geometric and geopotential altitude; Hydrostatic equation;Definition of standard atmosphere; Pressure, density & temperature altitudes. **Basic Aerodynamics:** Introduction to principle of flight; Ideal fluid, viscous flows, laminar and turbulent flows; Flow past a body, bluff bodies versus streamlined body, concept of boundary layer, flow separation, generation of lift, drag & moment, types of drag, non-dimensional coefficients; Airfoil, airfoil geometry, flow over airfoil, centre of pressure and aerodynamic centre, airfoil families; Wings, wing planform and orientation, flow over finite wing, wingtip devices; Propagation of sound, different flight regimes, critical and drag divergence Mach number, wave drag, swept wing, delta wing. **Aerospace Structures:** Basic function of aircraft structure; Aircraft configuration and principle types of construction; Details of constructional features of conventional aircraft; Use of metallic, non-metallic and composite materials; Introduction to landing gears. **Aerospace Propulsion:** Fundamental gas turbine cycle and propulsion techniques; Mechanism of thrust production in propellers and jet engines, comparative merits; Different types of aircraft engines; Principles of operation of rocket, rocket engine, typical applications, Jet Assisted Take-Off. **Basic Flight Mechanics:** Forces and moments on airplane; Significance of L/D ratio; Aircraft Drag Polar; High lift devices; Equation of motion; Thrust and power required for steady level flight; Thrust and power available and maximum velocity for jet engine and reciprocating engine-propeller combination; Climbing flight, Absolute and service ceilings; Gliding flight; Turning flight; Concepts of stability & control; Primary and secondary control surfaces; Criteria for longitudinal static stability, neutral point; Lateral-directional stability and control; Basic manoeuvres. **TOTAL**	**40**
	TEXT BOOKS	**Year**

1	"Introduction to Flight", J.D. Anderson, McGraw Hill Education	2010
2	"Understanding Flight", D. Anderson & S. Eberhardt, McGraw HillEducation	2000
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1	"Flight without Formulae", A.C. Kermode, Pearson Education	2000
2	"Fundamentals of Flight", Richard Shepherd Shevell, Pearson Education	1989
3	"The Airplane: A History of its Technology", J.D. Anderson, AIAA	2003
4	"Flight: The Complete History of Aviation", R.G. Grant, DK Publishing	2017
5	"Introduction to Aerospace Engineering with a Flight Test Perspective", Stephen Corda, Wiley-Blackwell	2017

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU3	**Introduction to Aeronautics**	**C01**	Explain physical properties and structure of atmosphere.
		C02	Correlate various basic aerodynamic parameters, and explain aerodynamic characteristics of airfoil and wing.
		C03	Know basic functions of aircraft structure.
		C04	Compare mechanism of thrust production in different types of aircraft engines.
		C05	Develop an understanding about performance, stability and control of aircraft.

CO-PO MAPPING

Introduction to Aeronautics	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	2	1											1	
	C02	3	3											3	2
	C03	2												1	
	C04	3	2											2	2
	C05	3	2											2	2
	Average	**2.6**	**2.0**											**1.8**	**2**

3ANU4: AIRCRAFT MATERIALS ENGINEERING

B.TECH (Aeronautical) 3rd semester

(3L+0T)

3ANU4	CONTENTS	HOURS
	Atomic Structure of Metals: Crystal structure; Crystal lattice of BCC, FCC & HCP, crystallographic notation of atomic planes and directions (Miller Indices); Polymorphism and allotropy; Imperfections in crystals. **Theories of Plastic Deformation:** Phenomenon of slip, twinning, recovery, recrystallization and grain growth; Iron carbon equilibrium diagram, phase transformation in the iron carbon diagram, formation of austenite, transformation of austenite into pearlite, martensite transformation in steel; TTT curves. **Heat Treatment Processes of Engineering Materials:** Principles and applications of annealing, normalizing, hardening, and tempering; Chemical heat treatment of steels − carburizing, nitriding, cyaniding, carbo-nitriding of steel. **Broad Classification of Engineering Materials:** Ferrous materials, nonferrous materials and alloys; Classification of steels, BIS standards; Ceramic materials; Fibre reinforced composite materials and polymers; Maraging steels and super alloys; Effects of alloying element on the structure and properties of steel, distribution of alloying elements (Si, Mn, Ni, Cr, Mo, Co, W, Ti, Al)in steel. **Materials in Aircraft Constructions:** Aluminium, titanium, copper, magnesium based alloys, steels; Composite materials. **Corrosion:** Detection and prevention; Protective coatings. **Testing:** Destructive and non-destructive testing techniques; Crack detection; Inspection of parts by hot oil and chalk, dyepenetrant, fluorescent and magnetic particles, X-ray, ultrasonic, eddy current and acoustic emission methods. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Aircraft Materials and Processes", G.F. Titterton, Himalayan Books	2015
2	"Materials Science and Engineering", W.D. Callister Jr., D.G. Rethwisch, John Wiley & Sons	2006
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Aircraft Materials and Analysis", Tariq Siddiqui, McGraw-Hill	2014

2.	"Aircraft Materials & Processes", Dorothy Kent, Shroff Publication	1998
3.	"Materials Science and Engineering: A First Course", V. Raghavan, PHI Learning Private Limited	2015
4.	"Material Science and Engineering", W.F. Smith, J. Hashemi & R. Prakash, McGraw Hill Education	2017

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU4	AIRCRAFT MATERIALS ENGINEERING	**C01**	The students will realize the significance of materials in aircraft engineering.
		C02	The students will have a knowledge of different kind of metal alloys used in aircrafts.
		C03	The students will have a knowledge of different kind high strength and heat resistant alloys used in aircrafts.
		C04	The students will have a knowledge of heat treatment processes and corrosion resistance metal alloys used in aircrafts.
		C05	The students will have a knowledge of modern materials.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
AIRCRAFT MATERIALS ENGINEERING	**C01**	3	3	2									2		
	C02	3	3	1	2										
	C03	3	3	1	2										
	C04	2	3	3	3	2							3		
	C05	2		3		3							3		
	Average	**2.6**	**3**	**2**	**2.33**	**2.5**							**2.6**		

3ANU5: MANUFACTURING PROCESSES

B.TECH (Aeronautical) 3rd semester

(3L+0T)

3ANU5	CONTENTS	HOURS
	Introduction: Importance of manufacturing, survey of manufacturing processes. **Foundry:** Casting process; Patterns— types, materials and allowances; Types of moulds; Core & core prints; Gating system; Introduction to special casting methods; Casting defects. **Metal Joining Processes:** Principle of welding, soldering, brazing and adhesive bonding; Arc welding, TIG, MIG; Gas welding and cutting; Thermite welding; Resistance welding; Spot, projection & seam welding; Atomic hydrogen, ultrasonic, plasma, laser & electron beam welding; Friction and explosive welding; Welding defects. **Forming and Shaping Processes:** Metal working, elastic and plastic deformation, concept of strain hardening, hot and cold working; Rolling principle and operations; Forging, hammers and presses; Extrusion, wire and tube drawing processes; Cold working processes— shearing, drawing, squeezing, blanking, piercing, deep drawing, coining & embossing, riveting, thread rolling, bending; Metal working defects. **Powder Metallurgy:** Methods of powder manufacturing; Properties of metal powders; Compacting; Sintering; Applications of powder manufacturing, advantages and limitations of powder manufacturing. **Rapid Prototyping Operations:** Additive & subtractive processes; Introduction to different additive manufacturing processes; Virtual Prototyping. **Plastic Technology:** General properties of plastics, classification of plastics; Ingredients of moulding compounds; Introduction to different plastic part manufacturing processes. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Manufacturing Technology", P.N. Rao, Tata McGraw Hill	2003
2	"Manufacturing Processes for Engineering Materials", S. Kalpakjian & S.R. Schmid, Pearson Education	2018
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**

1.	"Manufacturing Science", A. Ghosh & A.K. Mallik, Pearson India	2011
2.	"Introduction to Manufacturing Processes", John A. Schey, McGraw-Hill Education	2012
3.	"Elements of Manufacturing Processes", B.S. Nagendra Parashar & R.K. Mittal, PHI Learning Private Limited	2022
4.	"Manufacturing Science", A. Ghosh & A.K. Mallik, Pearson India	2011

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU5	**Manufacturing Processes**	**C01**	classify and introduce different primary manufacturing processes
		C02	explain principles, materials and methods of foundry technology
		C03	illustrate principles, materials and methods of forming processes
		C04	explain principles, materials and methods of metal joining.
		C05	differentiate powder metallurgy process, its application from other processes.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Manufacturing Processes	**C01**	3													
	C02	3	2	2	1										
	C03	3	2	2	1										
	C04	3	2	2	1										
	C05	3	2	2	1										
	Average	**3**	**2**	**2**	**1**										

3ANU6: ADVANCED ENGINEERING MATHEMATICS-1

B.TECH (Aeronautical) 3rd semester

(3L+0T)

3ANU6	CONTENTS	HOURS
	Laplace Transform: Definition and existence of Laplace transform, properties and formulae, unit step function, Dirac Delta function, Heaviside function; Inverse Laplace transform; Convolution theorem; Application of Laplace transform to ordinary differential equation. **Fourier Transform:** Fourier complex, sine and cosine transform, properties and formulae; Inverse Fourier transforms, Convolution theorem; Application of Fourier transforms to partial differential equation (1D heat and wave equations). **Z-Transform:** Definition, properties and formulae; Convolution theorem; Inverse Z-transform, application of Z-transform to difference equation. **Numerical Analysis:** Interpolation; Difference operators: forward, backward, central, shift and average operators; Newton's forward and backward interpolation formulae; Gauss's forward and backward interpolation formulae; Stirling's formula; Lagrange interpolation formula for unequal intervals; Inverse interpolation. **Numerical Differentiation:** Newton's, Gauss's and Stirling's formula. **Numerical Integration:** Trapezoidal Rule; Simpson's 1/3 and 3/8 rule. **Numerical Solution of ODEs of First Order:** Picard's method; Euler's method; Modified Euler's method; Runge-Kutta fourth order method; Milne's method. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Advanced Engineering Mathematics", R.K. Jain &S.R.K. Iyengar, Narosa Publications	2016
2	"Advanced Engineering Mathematics", O'Neil, Cengage Learning India	2011
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
5.	"Advanced Engineering Mathematics", E. Kreyszig, Wiley	2010
6.	"Advanced Engineering Mathematics", M. Greenberg, Pearson Education	2013

7.	"Advanced Engineering Mathematics", D.G.Zill& W.S. Wright, Jones & Bartlett India Private Limited	2008
8.	"Higher Engineering Mathematics", B.V. Ramana, McGraw Hill Education	2006

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU6	**ADVANCED ENGINEERING MATHEMATICS-1**	**C01**	:Know the basic concepts of integral transforms (Laplace and Fourier), Z-transform and difference operators along their fundamental properties.
		C02	Calculate the transforms of standard functions and elementary sequences, and work out numerical interpolation, differentiation and integration.
		C03	Apply the integral transforms, Z-transform and numerical methods to variety of problems, including differential, integral and difference equations.
		C04	Analyze the transforms and numerical tools needed to solve the practical problems in various branches of engineering.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
AERODYNAMICS – II	**C01**	3	2										1		
	C02	3	2												
	C03	2	3												
	C04	2	3												
	C05														
	Average	**2.5**	**2.5**										**1**		

3ANU7: INTRODUCTION TO AERONAUTICS LAB

B.TECH (Aeronautical) 3rd semester

3P

3ANU7	CONTENTS
	• Acquaintance with the concept of static stability and control • Depiction of the use of aircraft primary control surfaces along with their locations on aircraft • Smoke visualization over cylinder and airfoil section to show boundary layer separation • Demonstration of foldable landing gear and damping in landing gear • Illustration of different types of UAVs • Review of different classes of flying vehicles • To study various types of engines used in aircraft • Discussion on Aircraft Traffic Control System along with its demonstration of its working • Study of constructional details of aircraft fuselage and wings • Display of different types of high lift devices and drag inducing devices

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU7	Introduction to Aeronautics Lab	**C01**	Familiarization with basic concepts of aeronautics.
		C02	Use of simple equipment to illustrate working of components.
		C03	Demonstration of parts of aircraft, such as wings, tails, landing gear and control surfaces.
		C04	Ability to use wind tunnel for simple experiments such as flow visualization.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Introduction to Aeronautics Lab	**C01**	3	1	2									2		
	C02	3	2	3	1	2									
	C03	3	1	2		2									
	C04	3	2	2	2	2							1		
	Average	**3**	**1.5**	**2.25**	**1.5**	**2**							**1.5**		

3ANU8: FLUID MECHANICS LAB

B.TECH (Aeronautical) 3rd semester

3P

3ANU8	CONTENTS
	• Determination of meta-centric height of a given body • Determination of Cd, Cv & Cc for given orifice • Calibration of contracted rectangular notch and triangular notch and determination of flow rate • Determination of velocity of water by Pitot tube • Verification of Bernoulli's theorem • Calibration and flow rate determination using venturimeter and orificemeter • Determination of head loss in given length of pipe • Determination of the Reynolds number for laminar, turbulent and transient flow in pipe • Determination of coefficient for minor losses in pipes • Measurement of velocity distribution in a pipe and calculation of discharge • Measurement of boundary layer velocity profile over a flat plate and to determine the boundary layer thickness

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU8	FLUID MECHANICS LAB	**C01**	Develop procedure for standardization of experiments.
		C02	Calibrate flow discharge measuring device used in pipes channels and tanks.
		C03	Determine fluid and flow properties.
		C04	Illustrate laminar and turbulent flows.
		C05	Test the performance parameters for flow through pipes.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
FLUID MECHANICS LAB	**C01**	3	2	2	3	2									
	C02	3	3	2	3	3									
	C03	3	3	2	3	3									
	C04	3	2	2	3	2									
	C05	3	3	2	3	2									
	Average	**3.0**	**2.6**	**2.0**	**3.0**	**2.4**									

3ANU9: MECHANICS OF SOLIDS LAB

B.TECH (Aeronautical) 3rd semester

3P

3ANU9	CONTENTS
	• Introduction to Universal Testing Machine • Use of Izod Impact Tester to measure impact loads • Calculation of Young's modulus of aluminum and steel • Determination of fracture strength and fracture pattern of ductile & brittle materials • Testing torsion load using Torsion Tester • Measurement of buckling load for columns • Performing tensile test and characterizing elastic limit, strain hardening, necking and yield point • Compression testing of a metal chip and calculation of compressive strength • Shear testing • Bending test and determination of Young's Modulus of Elasticity via deflection of beam • Performing fatigue test on a given material and to determine its fatigue strength • Creep testing and its significance

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU9	Mechanics of Solids Lab	**C01**	Understand the mechanical properties of materials.
		C02	Mechanical properties of materials under different types of loadings.
		C03	Ability to perform tension and compression test.
		C04	Ability to perform hardness and torsion test.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Mechanics of Solids Lab	**C01**	2	1	-	1										
	C02	2	2	1	2										
	C03	2	2	1	2										
	C04	2	2	1	2										
	Average	**2**	**1.75**	**1**	**1.75**										

3ANU10: AIRCRAFT MATERIALS LAB

B.TECH (Aeronautical) 3rd semester

3P

3ANU10	CONTENTS
	• Characterization of important engineering materials and crystal structures • Demonstration of brittle and ductile fracture • Illustration of micro structures of steel using charts • Calculation of hardness using Rockwell Hardness Tester • Calculation of hardness using Brinell hardness Tester • Calculation of hardness using Vickers Hardness Tester VM-50 • Heat treatment experiments such as annealing, quenching, case hardening and their effect on hardness • Effect of carbon percentage on the hardness of steel • Study of Fe-C diagram • Depiction of various crystal structures and dislocations through models • Introduction to NDT methods

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU10	Aircraft Materials Lab	**C01**	The students will realize the significance of materials in aircraft engineering.
		C02	The students will have a knowledge of different kind of metal alloys used in aircrafts.
		C03	The students will have a knowledge of different kind high strength and heat resistant alloys used in aircrafts.
		C04	The students will have a knowledge of heat treatment processes and corrosion resistance metal alloys used in aircrafts.
		C05	The students will have a knowledge of modern materials.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Aircraft Materials Lab	**C01**	3	3	2									2		
	C02	3	3	1	2										
	C03	3	3	1	2										
	C04	2	3	3	3	2							3		
	C05	2		3		3							3		
	Average	**2.6**	**3**	**2**	**2.33**	**2.5**							**2.6**		

3ANU11: PROFESSIONAL SKILL LAB

B.TECH (Aeronautical) 3rd semester

3P

3ANU11	CONTENTS
	Personality Assessment Skills: Personal SWOT analysis activities, leveraging personal strengths, self-evaluation, self-criticism, self-discipline; Mock interviews. **Time Management Skills**: Learning methodology for achieving targets and setting priorities. **Conflict Management Skills**: Learning negotiation and conflict resolution skills through simulation exercise. **Leadership Skills:** Assertiveness, innovation & creativity; Discussions on successful leaders and entrepreneurs. **Motivational Skills**: Motivational theories and their practical applications, ability to motivate self and others. **Stress Management Skills**: Practice different methods of stress management; Introduction to Yoga & Pranayama, use of prayer and meditation; Effective use of music for relieving stress and enhancing concentration & consistency. **Group Dynamics:** Group discussion, video samples of mock GD; Role plays; In-basket exercises. **Behavioural Skills**: Attitude and altitude; Lateral thinking; Psychometrics; Case studies and video samples.

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANU11	PROFESSIONAL SKILL LAB	**C01**	Plan the activities related to self-analysis and management.
		C02	Exercise the activities for managing and developing the various skills. such as leadership and motivational skills.
		C03	Interpret the various professional behavior and activities.
		C04	Prepare and develop the personality by performing different actions.
		C05	Exercise on different methods of time management and stress management.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01		1	1	1	1				3	2	2			
	C02		1	1	1		1			3	2	2			
	C03		1	1	1		1		1	2	3	1			
	C04		1	1	1		1		1	2	3	2			
	C05		1	1	1				1	2	3	1			
	Average		**1**	**1**	**1**	**1**	**1**		**1**	**2.4**	**2.6**	**1.6**			

3ANUDC: DISCIPLINE & EXTRA-CURRICULAR ACTIVITIES

B.TECH (Aeronautical) 3rd semester

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANUDC	Discipline & Extra-Curricular Activities	**C01**	Recognize their strength and those of others to work towards a shared vision (leadership).
		C02	Develop and sustain healthy and meaningful relationship with others (Interpersonal skills).
		C03	Identify and address the needs of the community collaboratively to facilitate positive social change (Social Responsibility).
		C04	Generate innovations through experimentation with novel ideas, forms, and methods (Critical and creative thinking).
		C05	Act as a disciplined citizen with ethical and moral values.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Discipline & Extra-Curricular Activities	**C01**						2	1	3	2	1		2		
	C02						2	1	2	3	3		1		
	C03						3	2	2	2	2		2		
	C04	3	2	2	2	2		1		2	1		2		
	C05						2	1	3	1	1		2		
	Average	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.3**	**1.2**	**2.5**	**2.0**	**1.6**		**1.8**		

4ANU1: AERODYNAMICS – I

B.TECH (Aeronautical) 4th semester

(3L+0T)

4ANU1	CONTENTS	HOURS
	Basic Fluid Mechanics Concepts: Streamlines and streamfunction; Vorticity, circulation, relation between circulation and vorticity; Kelvin's theorem; Helmholtz theorems. **Potential Flow:** Velocity potential; Laplacian flow, principle of superposition; Elementary flows: uniform flow, source, sink, vortex & doublet; Potential flow past stationary and rotating circular cylinder, d'Alembert paradox, Magnus effect; Kutta-Joukowski theorem; Blasius theorem. **Flow over Airfoils:** Airfoil geometry, angle of attack, sectional forces and moment coefficients, centre of pressure and aerodynamic centre; Kutta condition; Introduction to conformal mapping, Kutta-Joukowski transformation; Thin Airfoil Theory, Theodorsen's condition; Real flow effects, effect of angle of attack on pressure distribution, airfoil stall, profile drag. **Flow over Finite Wings:** Wing geometry, forces and moment coefficients; Wingtip vortices, downwash, induced drag; Lifting Line Theory and its limitations, elliptical and general lift distribution; Simplified horseshoe vortex; Qualitative discussion of flow over delta wings. **Experimental Aerodynamics:** Components of wind tunnel, flow quality; Correlation of experimental results to actual prototypes, effect of Reynolds number and freestream turbulence; Flow visualization techniques, Basics of pressure, velocity and force measurement. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Fundamentals of Aerodynamics", J.D. Anderson, McGraw-Hill Higher Education	2016

2	"Aerodynamics for Engineering Students", E.L. Houghton, P.W. Carpenter, S. Collicott & D. Valentine, Elsevier	2012
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Aerodynamics for Engineers", J.J. Bertin & R.M. Cummings, Pearson Education India	2015
2.	"Theoretical Aerodynamics", E. Rathakrishnan, John Wiley & Sons	2022
3.	"Basic Aerodynamics: Incompressible Flow", G.A. Randro, H.M. Macmohan & R.L. Roach, Cambridge University,Prss	2010
4.	"Low Speed Aerodynamics", K. Ghosh, PHI Learning	2018

COURSE OUTCOME

Course Code	**Course Name**	**Course Outcome**	**Detail**
4ANU1	**AERODYNAMICS – I**	**C01**	Apply conservation laws to solve incompressible flow regime.
		C02	Solve the problems on potential flows.
		C03	Apply Joukowski theorem to fluid flow problems.
		C04	Explain airfoil and wing characteristics.
		C05	Apply thin airfoil theory to predict performance.
		CO6	Measure the aerodynamic forces on various aerodynamic bodies

CO-PO MAPPING

AERODYNAMICS – I	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01		2		1										
	C02	3													
	C03	3	2											2	
	C04		3											2	
	C05	3	2			2									
	CO6				3			1						3	
	Average	**3**	**2.25**		**2**	**2**		**1**						**2.33**	

4ANU2: ENGINEERING THERMODYNAMICS

B.TECH (Aeronautical) 4th semester

(3L+0T)

4ANU	CONTENTS	HOURS
	Fundamental Concepts: Thermodynamic system and control volume; Open, closed & isolated systems, thermodynamic properties, state and path variables, processes & cycles; Temperature & zeroth law of thermodynamics; Quasi-static process;Equation of state of perfect gas, difference between gas & vapour. **First Law of Thermodynamics**: First law for a closed system undergoing a change of state, heat & work, mechanical & nonmechanical forms of work, change in internal energy, heat transferred during various thermodynamic processes, P-V diagrams; First law applied to flow processes (control volume systems). **Second Law of Thermodynamics**: Kelvin-Plank & Clausius statements, heat engines, refrigerator & heat pump; Perpetual motion machines; Reversible & irreversible processes, availability, irreversibility; Introduction to entropy, principle of increase of entropy, Clausius inequality; Carnot cycle; Maxwell's relations. **Properties of Steam:** Critical state, sensible heat, latent heat, saturated & superheated steam, wet steam, dryness fraction, internal energy of steam, Mollier chart; Work & heat transfer during various thermodynamics processes with steam as working fluid; Clausius-Clapeyron equation and Joule-Thomson coefficient. **Air Standard Cycles:** Otto cycle; Diesel cycle; Stirling & Ericsson cycle; Brayton cycle; Joule cycle. **Vapour Cycles**: Simple & modified Rankine cycle with reheat & regeneration. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Thermodynamics: An Engineering Approach", Y.A. Cengel & M.A. Boles, McGraw Hill Education	2019

2	"Engineering Thermodynamics", P.K. Nag, McGraw Hill Education	2013
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Fundamentals of Classical Thermodynamics", G.J. Van Wylen and R.E. Sonntag, John Wiley & Sons	1994
2.	"Thermodynamics", W.C. Reynolds & H.C. Perkins, McGraw-Hill	1979
3.	"Engineering Thermodynamics: Work and Heat Transfer", G. Rogers and Y. Mayhew, Longman Scientific	1992
4.	"Fundamentals of Engineering Thermodynamics", M.J. Moran & H.N. Shapiro, John Wiley & Sons Inc.	2018

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Details
4ANU2	**ENGINEERING THERMODYNAMICS**	**CO1**	Apply concepts of TD and Zeroth Law in solving numerical problems with relevant units
		CO2	Analyze and evaluate different forms work, heat and other properties by applying 1st Law of TD
		CO3	Evaluate COP, EER, Efficiency, temperature and entropy by applying second law of TD and its corollaries.
		CO4	Illustrate problem solving procedure related to pure substances, ideal and real gases using PT, PV, TH diagrams
		CO5	Correlate various thermodynamic variables in thermodynamic relations. Evaluate vapour and gas power cycles, its components and summarize performance on the basis of different parameters

CO-PO MAPPING

ENGINEERING THERMODYNAMICS	Course Outcomes	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12
	CO1	3	3	1									1
	CO2	3	3	2	2								2
	CO3	3	3	2	2			2					2
	CO4	3	3	1									
	CO5	3	3	1									
	CO6	3	3	2	3			2					2
	Average	3	3	1.5	2.33			2					1.75

4ANU3: AIRCRAFT STRUCTURES – I

B.TECH (Aeronautical) 4th semester

(3L+0T)

4ANU3	CONTENTS	HOURS
	Introduction: Features of aircraft structures, monocoque and semi-monocoque structures, structural idealization, nomenclature & layout, functions of different structural members; Static equilibrium, statically determinate and indeterminate structures; Concept of static stability. **Statically Determinate Structures:** Analysis of framed structures; Planar truss analysis— method of joints, method of sections, method of moments; Space truss analysis, 3d truss tension coefficients. **Statically Indeterminate Structures:** Degree of indeterminacy; Bending & tension of fixed beams, composite beam, stress resultants, modulus weighted section properties; Clapeyron's three moment equation; Moment distribution method. **Deformations due to Loading:** Differential equation of the elastic curve due to composite loading, double integration and moment area methods; Conjugate beam method; Macaulay's method; Principle of superposition. **Energy Methods:** Work and energy principles, strain energy and complementary strain energy; Principal of virtual work, Principal of virtual displacement; Maxwell's Reciprocal theorem; Potential and complementary potential theorems; Castigliano's theorem, unit load method, application of energy principles in analysis of determinate and indeterminate structures. **Failure Theories:** Maximum principle stress theory; Maximum principle strain theory; Distortion Theory; Maximum strain energy theory; Octahedral shear stress theory; Fatigue; Creep; Application to aircraft structural problems. **TOTAL**	**40**

	TEXT BOOKS	Year
1	"Aircraft Structures for Engineering Students", T.H.G. Megson, Butterworth-Heinemann	2017
2	"Analysis of Aircraft Structures : An Introduction", B.K. Donaldson, Cambridge University Press	**2008**
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Theory and Analysis of Flight Structures", R.M. Rivello, McGraw-Hill	2006
2.	"Introduction to Aerospace Structural Analysis", D.H. Allen & W.E. Haisler, John Wiley & Sons	1985
3.	"Aircraft Structures", D.J. Peery, Dover Publications Inc.	2012
4.	"Understanding Aircraft Structures", J. Cutler & J. Liber, Wiley-Blackwell	2006

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU3	**AIRCRAFT STRUCTURES – I**	**C01**	Identify statically determinate and indeterminate structures.
		C02	Analyze the response of statically determinate structures under various loading conditions.
		C03	Calculate deformation of simple structural element under different kinds of loads.
		C04	Determine the reactions of structures using strain energy concept.
		C05	Examine the structural failures using failure theories.

CO-PO MAPPING

Aircraft Structures – I	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	3	2											3	
	C02	3	3		1									3	
	C03	3	3											3	
	C04	3	3		2									3	2
	C05	3	3		2									3	2
	Average	**3**	**2.8**		**1.67**									**3**	**2**

4ANU4: THEORY OF MACHINES

B.TECH (Aeronautical) 4th semester

(3L+0T)

4ANU4	CONTENTS	HOURS
	Kinematics: Links, pairs, mechanisms, four bar chain and its inversions; Velocity and acceleration, Klein's construction, Coriolis component; Instantaneous center method, pantograph; Scott-Russel, Tchbeicheff straight line, indicator diagram mechanisms. **Friction:** Laws of static, dynamic and rolling friction, dry and viscous friction; Inclined plane and screw jack; Pivots, clutches; Brakes: Band, block and band & block brakes, braking action. **Dynamometers:** Absorption and transmission type dynamometers, prony, rope and hydraulic dynamometers. **Gears:** Laws of gearing, gears terminology; Interference, undercutting and minimum number of teeth on pinion in contact with gear; Spur, helical, bevel gear, rack and pinion mechanism. **Gear Trains:** Simple, compound, reverted and epicyclic gear trains, analytical and tabular methods for velocity ratio; Gear boxes. **Gyroscope:** Principle of gyroscopic couple, effect of gyroscopic couple and centrifugal force on airplanes taking a turn. **Balancing:** Balancing of rotating masses; Balancing of reciprocating masses; Balancing of inline engines and V-engines. **TOTAL**	**40**

	TEXT BOOKS	Year
1	"Theory of Machines", S.S Rattan., McGraw Hill	2014
2	"Theory of Machines and Mechanisms", Uicker, Pennocle & Shigley, Oxford University Press	2014
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Theory of Mechanisms and Machines", A. Ghosh, Affiliated East West Press	2013
2.	"Theory of Machines", Thomas Bevan, Pearson Education	2009
3.	"Mechanism and Machine Theory", A. G. Ambekar, Prentice-Hall Of India	2007
4.	"Theory of Mechanisms and Machines", Sharma & Purohit, Prentice-Hall Of India	2006

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU4	**Theory of Machines**	**C01**	Apply the fundamental concepts in developing various mechanisms.
		C02	Analyze velocity and acceleration in planar mechanisms.
		C03	Synthesize simple mechanisms such as 4-bar and slider crank mechanisms.
		C04	Understanding the concept of gyroscopic and balancing.
		C05	Determine appropriate gears for requirements.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Theory of Machines	**C01**	1												**1**	
	C02	3	2		1					**1**				2	
	C03	2												2	
	C04	2	2		1									2	
	C05	2								**1**				2	
	Average	**2**	**2**		**1**					**1**				**1.8**	

4ANU5: MACHINE DESIGN

B.TECH (Aeronautical) 4th semester

(3L+0T)

4ANU5	CONTENTS	HOURS
	Materials: Mechanical Properties; Selection of material from properties and economic aspects. **Manufacturing Considerations**: Standardization, interchangeability, limits, fits, tolerances and surface roughness, BIS. **Design for Strength:** Allowable stresses, detailed discussion on factor of safety; Introduction of various design considerations like strength, stiffness, weight, cost, space etc.; Modes of failure, strength and stiffness considerations; Stress concentration, causes and mitigation. **Design of Members in Bending:** Beams, levers. **Design of Members in Torsion**: Shafts and shaft couplings, design of keys. **Design of Bearing:** Bearing classification, Methods of lubrication, hydrodynamic, hydrostatic, boundary etc.; Journal bearing, minimum film thickness, Sommerfield number, thermal equilibrium; Selection of anti-friction bearings for different load cycles, bearing life, static & dynamic load carrying capacity. **Fatigue Considerations in Design:** Variable load, loading pattern, endurance stresses; Influence of size, surface finish, notch sensitivity and stress concentration; Goodman line, Soderberg line & Gerber line; Design of machine members subjected to combined,	

	steady and alternating stresses; design of shafts under variable stresses, bolts subjected to variable stresses. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Design of Machine Elements", V.B. Bhandari, McGraw Hill Education	**2013**
2	"Shigley's Mechanical Engineering Design", R.G. Budynas & J.K. Nisbett, McGraw Hill Education	**2015**
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Analysis and Design of Machine Elements", V.K. Jadon & S. Verma, I.K. International Publishing House Pvt. Ltd.	**2014**
2.	"A Text Book of Machine Design", A. Karwa, Laxmi Publication	**2005**
3.	"Machine Design", Hall, Holwenko & Laughlin, Schaum's Outlines Series, McGraw Hill	**1968**
4.	"Mechanical Machine Design", Bahl & Goel, Standard Publishers Distributors	**2002**

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU5	**Machine Design**	**C01**	Select the material to be used for an application based on its properties and understand its BIS nomenclature.
		C02	Make use of manufacturing considerations in designing a part and select a suitable fit for mating of two parts.
		C03	Determine the sizes of the parts of cotter and knuckle joints considering various modes of failure.
		C04	Design the shaft under combined loading and shaft - coupling under torsional loading.
		C05	Design the bending members like Lever and laminated spring based on strength and stiffness consideration.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Machine Design	C01	3	2	2	2		2								
	C02	2	2	3	2										
	C03	3	3	2	2										
	C04	3	3	2	2										
	C05	3	3	2	2										
	Average	2.8	2.6	2.2	2		2								

4ANU6: ADVANCED ENGINEERING MATHEMATICS – II

B.TECH (Aeronautical) 4th semester

(3L+0T)

4ANU6	CONTENTS	HOURS
	Complex Analysis: Differentiability and analytic functions; Cauchy-Riemann equations (in Cartesian and polar forms),harmonic functions; Conformal mapping; Complex Line integral, M-L inequality; Cauchy theorem, Cauchy integral formulae; Taylor series and Laurent series; Singularities and zeros, residues at poles and infinity, residues at isolated essential singular point; Cauchy residue theorem, evaluation of real definite integrals and improper integrals. **Special Functions**: Legendre's function, generating function, simple recurrence relations, orthogonal property; Bessel's functions of first and second kind, generating function, simple recurrence relations, orthogonal property. **Statistics & Probability**: Basic concepts of probability, conditional probability; Baye's theorem; Random variable and distributions: Discrete and continuous random variables, moments, expectation, moment generating function; Binomial, Poisson and normal distribution **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Advanced Engineering Mathematics", R.K. Jain & S.R.K. Iyengar, Narosa Publications	**2002**
2	"Introduction to Probability and Statistics", S. Lipschutz & J.J. Schiller, McGraw Hill Education	**2012**
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**

1.	"Advanced Engineering Mathematics", I. Kreyszig, Wiley India	**2010**
2.	"Advanced Engineering Mathematics", D. Zill & W. Wright, Jones & Bartlett India Private Limited	**2012**
3.	"Complex Variables and Applications", J.W. Brown & R.V. Churchill, McGraw Hill Education	**2021**
4.	"Probability and Statistics", M. Spiegel, J. Schiller & R.A. Srinivasan, McGraw Hill Education	**2009**

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU6	**Advanced Engineering Mathematics – II**	**C01**	Illustrate basic concepts of complex analysis, special function, statistics and probability distribution.
		C02	Evaluate the analyticity, singularities and integral of a complex valued function.
		C03	Understand the fundamental properties and applications of Bessela and Legendre functions.
		C04	Apply the concept of probability and statistics to find the physical significance of various distribution.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Advanced Engineering Mathematics – II	**C01**	3	2												
	C02	2	3												
	C03	3	2												
	C04	2	3												
	Average	**2.5**	**2.5**												

4ANU7: AERODYNAMICS LAB

B.TECH (Aeronautical) 4th semester

3P

4ANU7	CONTENTS
	• Study of components of subsonic wind tunnel and its calibration • Measurement of pressure distribution over smooth and rough cylinder • Measurement of pressure distribution over symmetric and cambered airfoils • Force measurement using strain guage balance over models of different shapes • Flow visualization of flow over a delta wing at different incidences • Smoke flow visualization over airfoil and cylinder • Boundary layer measurements over flat plate • Calculation of displacement thickness over airfoil at different locations • Calibration of hot wire anemometer and freestream turbulence measurement • Use of pressure sensors for pressure measurement • Study of velocity measurement using LDV & PIV • Characterization of subsonic jets

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU7	AERODYNAMICS LAB	**C01**	Describe components of wind tunnel.
		C02	Understand calibration of wind tunnel test section.
		C03	Determine pressure distribution and force over different shapes models.
		C04	Identify flow pattern over airfoil and cylinder.
		C05	Evaluate boundary layer measurements.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
AERODYNAMICS LAB	**C01**		1											2	
	C02		2		3									2	
	C03	3	2	2	3									2	
	C04	3	2	2	3									2	
	C05	3	2	3	3									2	
	Average	**3**	**1.8**	**2.33**	**3**									**2**	

4ANU8: MANUFACTURING TECHNOLOGY LAB

B.TECH (Aeronautical) 4th semester

3P

4ANU8	CONTENTS
	Machine Shop • Study of lathe machine, lathe tools, cutting speed, feed and depth of cut • To perform step turning, knurling and chamfering on lathe machine as per drawing • Taper turning by tailstock offset method as per drawing • To cut metric thread as per drawing • To perform square threading, drilling and taper turning by compound rest as per drawing • To study shaper machine and its mechanism • To study the milling machine, milling cutters, indexing heads and indexing methods and to prepare a gear on milling • machine • Study of single point cutting tool geometry and to grind the tool as per given geometry **Foundry Shop** • To prepare mould of a given pattern requiring core and to cast it in aluminum • Moisture test and clay content test • Strength test (compressive, tensile, shear transverse etc. in green and dry conditions)

	• Hardness test (mould and core) • Permeability test • A.F.S. sieve analysis test **Welding Shop** • Hands-on practice on spot welding • Hands-on practice on submerged arc welding • Hands-on practice on metal inert gas welding (MIG) and tungsten inert gas welding (TIG)

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU8	Manufacturing Technology Lab	**C01**	To learn parametric aspects of machining, working principle and machining process.
		C02	Learn and practice the machining operation and tools used in machining.
		C03	Understand and perform sand mould testing methods.
		C04	Learn and perform the gas, arc, spot welding operations.
		C05	Learn to operate the machine used in mechanical engineering workshop.

CO-PO MAPPING

Manufacturing Technology Lab	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	3	2	2			1								
	C02	3	3												
	C03	3	3				1								
	C04	3	3	2			2								
	C05	3	3	3			1								
	Average	**3**	**2.8**	**2.3**			**1.3**								

4ANU9: AIRCRAFT STRUCTURES LAB

B.TECH (Aeronautical) 4th semester

3P

4ANU9	CONTENTS
	• Study of construction of fuselage and identification of primary load carrying members • Study of construction of wings, ailerons, flaps, slits, slats and spoilers • Study of construction of empennage, stabilizers, rudders adjusting tabs etc. with detail of honeycomb structure • Study of construction of landing gears and wheel turning mechanism • Study of aileron control linkages including artificial feel mechanism, booster and manual controls and their adjustments • Measurement of forces in statically indeterminate force system • Deflection of beams with various end conditions for different load • Determination of compressive strength of thin plates • Verification of Maxwell's Reciprocal theorem & principle of superposition • Measurement of strain using strain gauges • Shear centre location for open and closed sections • Estimation of the location of principle axes for a given section • Compression tests on long and short columns • Calibration of photoelastic materials • Dye penetrant testing for surface crack detection

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU9	Aircraft Structures Lab	**C01**	To calculate the Young's modulus of material, fracture strength and fracture pattern of ductile and brittle materials.
		C02	To compare the theoretical and experimental results of beams with various end conditions.
		C03	To evaluate the Maxwell's Reciprocal theorem and Principle of superposition using beams under various load conditions.
		C04	To analyze the theoretical and experimental results for axial loading on column members for the end conditions.
		C05	To estimate the shear center location for open and closed sections.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Aircraft Structures Lab	**C01**	2	3		2					1			1		
	C02	3								2		1			
	C03	2	3	1	3					1					
	C04	2	3		1								2		
	C05	3	1	1			1						2		
	Average	**2.4**	**2.5**	**1**	**2**		**1**			**1.3**		**1**	**1.6**		

4ANU10: OBJECT ORIENTED PROGRAMMING LAB

B.TECH (Aeronautical) 4th semester

3P

4ANU10	CONTENTS
	• Use of functions, arrays, strings etc. • Use of nested loops in applications • Brief introduction to pointers and referencing • Defining class and objects; use of objects as function parameters; friend functions • Different types of inheritance • Constructors and destructors • Function and operator overloading • Introduction to algorithms such as searching algorithms (linear search and binary search) and sorting algorithms

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU10	OBJECT ORIENTED PROGRAMMING LAB	C01	Understand use of arrays, strings and functions.
		C02	Identify use of nested loops and pointers.
		C03	Apply concept of class and objects.
		C04	Understand types of inheritance.
		C05	Learn about operator overloading.
		CO6	Develop code using searching and sorting algorithms.

CO-PO MAPPING

OBJECT ORIENTED PROGRAMMING LAB	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	2			2	3									1
	C02	2			2	3									1
	C03	2			2	3									1
	C04	2			2	3									1
	C05	2			2	3									1
	CO6	2			2	3									1
	Average	**2**			**2**	**3**									**1**

4ANU11: CONTEMPORARY CHALLENGES

B.TECH (Aeronautical) 4th semester

3P

4ANU11	CONTENTS
	Group discussions and presentations on various contemporary issues such as:- • Economic policies of nations affecting large number of people • Technological advancements and their consequences • Need for sustainable development • National and international policies of various countries • Civil and human rights • Education policy of state • Effect of historic and geographic conflicts on present society • Debates in political theories • Socio-cultural transformations and their effects

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANU11	Contemporary Challenges	**C01**	Analyze some of the real-life challenges facing the society and how to address them.
		C02	Collect information from various sources and examine technical and economic feasibility of the solution.
		C03	Propose effective use of technology for the benefit of environment.
		C04	Become sensitive towards diverse socio-economic conditions of different people.
		C05	Learn to communicate effectively and convince others.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Contemporary Challenges	**C01**		3	3	3		3	2	2	2			3		
	C02	2	3	3	2		2		2		2	3	3		
	C03	2	3	3	3	2	3	3	3		2	2	3		
	C04		2	2	2		3	2	3	2			3		
	C05						2			3	3		3		
	Average	**2**	**2.75**	**2.75**	**2.5**		**3.25**	**2.3**	**2.5**	**2.3**	**2.3**	**2.5**	**3**		

4ANUDC: DISCIPLINE & EXTRA-CURRICULAR ACTIVITIES

B.TECH (Aeronautical) 4th semester

3P

4ANUDC	CONTENTS
	As per UD, RTU norms

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
4ANUDC	Discipline & Extra-Curricular Activities	C01	Recognize their strength and those of others to work towards a shared vision (leadership)
		C02	Develop and sustain healthy and meaningful relationship with others (Interpersonal skills)
		C03	Identify and address the needs of the community collaboratively to facilitate positive social change (Social Responsibility)
		C04	Generate innovations through experimentation with novel ideas, forms, and methods (Critical and creative thinking)
		C05	Act as a disciplined citizen with ethical and moral values

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Discipline & Extra-Curricular	C01						2	1	3	2	1		2		
	C02						2	1	2	3	3		1		
	C03						3	2	2	2	2		2		
	C04	3	2	2	2	2		1		2	1		2		
	C05						2	1	3	1	1		2		
	Average	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.3**	**1.2**	**2.5**	**2.0**	**1.6**		**1.8**		

5ANU1: AERODYNAMICS – II

B.TECH (Aeronautical) 5th semester

(3L+0T)

5ANU1	CONTENTS	HOURS
	Basic Concepts: Compressibility; Laws of thermodynamics, perfect gas, internal energy, enthalpy, entropy; Mach number, fundamental difference between subsonic and supersonic flow, Mach angle, shock and Mach waves. **Steady One-Dimensional Isentropic Flow:** Continuity, momentum and energy conservation equations; Stagnation temperature and pressure; Expression for speed of sound; Area-velocity relation, flow in nozzles & diffusers, effect of back pressure. **Shocks:** Normal shock, normal shock relations for perfect gas, Prandtl relation; Rankine-Hugoniot equation; Moving normal shock; Oblique shocks, oblique shock relations, strong and weak shock solutions, shock polar, detached shock. **Expansion Waves:** Expansion fan, Prandtl-Meyer function, reflection and interaction of shocks and expansion waves. **Non-Isentropic 1D flow:** Rayleigh flow; Fanno flow. **Airfoils in Compressible flow:** Critical Mach number and critical pressure coefficient, drag divergence Mach number; Shock boundary layer interaction, shock induced separation; Whitecomb area rule, supercritical airfoil, swept and delta wings, supersonic aerofoils, wave drag; Similarity rules; Supersonic thin airfoil theory. **Introduction to Hypersonic flow:** Distinguishing phenomena in hypersonic flow; Basic hypersonic shock and expansion relations; Newtonian model.	

	Experiments in Compressible Flow: Transonic, supersonic and hypersonic tunnels and their peculiarities; Blowdown, indraft and continuous wind tunnels; Shock tubes; Pressure measurement; Velocity measurement; Optical methods of flow visualization. **TOTAL**	**40**
	TEXT BOOKS	
1	"Modern Compressible Flow", J.D. Anderson Jr., McGraw Hill	2003
2	"Gas Dynamics", E. Rathakrishnan, Prentice Hall of India Pvt. Ltd.	2014
	REFERENCE BOOKS	
S.NO.	**Name of author/Book/publisher**	**Year**
1	"The Dynamics and Thermodynamics of Compressible Flow", A.H. Shapiro, Wiley India	2008
2	"Elements of Gas Dynamics", H.W. Liepmann& A. Roshko, Wiley & Sons	1957
3	"Fundamentals of Gas Dynamics", R.D. Zucker& O. Biblarz, John Wiley & Sons	2002
4	"Compressible Fluid Flow", P.H. Oosthuizen& W.E. Carscallen, McGraw-Hill	2013
5	"Fundamentals of Gas Dynamics", M.J. Zucrow& J.D. Hoffman, Wiley India Private Limited	2019

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU1	AERODYNAMICS – II	**C01**	Apply the principles of Fluid Mechanics in designing & developing highly efficient aerodynamic bodies.
		C02	Signify the role of various fundamental potential flows in assessing the aerodynamic behaviour of various bodies.
		C03	Determine the Aerodynamic characteristics incompressible flows.
		C04	Evaluate aerodynamic performance characteristics of various aerodynamic bodies.

CO-PO MAPPING

Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
C01	3		2									2		2
C02	3	3		2									3	1
C03	3	3		3	2								3	2
C04	3	3		3									3	2
C05	3	2	2	2	2							2	2	2
Average	**3**	**2.75**	**2**	**2.5**	**2**							**2**	**2.8**	**1.8**

5ANU2: AIRCRAFT PERFORMANCE

B.TECH (Aeronautical) 5th semester

(3L+0T)

5ANU2	CONTENTS	HOURS
	Atmosphere: Need to define standard atmosphere; International Standard Atmosphere; Stability of atmosphere; Equivalent, calibrated and indicated airspeed; Primary flight instruments, ASI, VSI, turn-bank indicator. **Aerodynamic Characteristics:** Forces and moments acting on a flight vehicle, variation of aerodynamic coefficients with angle of attack, Reynolds number and Mach number; Effect of aspect ratio, planform, sweep, taper and twist on aerodynamic characteristics; Different types of drag, drag polar, design methods to reduce drag; Variation of thrust, power and SFC with velocity and altitudes for air-breathing engines. **Steady Level Flight:** Equations of motion; Thrust and power required for level unaccelerated flight; Maximum thrust and power available for jet engine and propeller engine, variation of thrust/power available and required with altitude; Maximum level flight speed, conditions for minimum drag and minimum power required; Stalling speed; Range and endurance of jet and propeller engine airplanes, condition for maximum range and endurance; Effect of altitude, weight and wind. **Climbing Flight:** Unaccelearated climb; Excess power; Maximum rate of climb and steepest angle of climb, time to climb, climb hodograph; Absolute and service ceilings; Accelerated rate of climb; Energy manoeuvrability. **Gliding Flight:** Steady descent, equilibrium glide angle, equilibrium glide velocity; Minimum rate of sink and shallowest angle of glide, maximum gliding range; Glide hodograph. **Take-off & Landing Performance:** Equations of motion during take-off and landing; Estimation of take-off and landing distances; Effect of head, tail and cross winds; Thrust augmentation, reverse thrust, jet assisted take-off system, spoilers.	

	Manoeuvring Flight: Level coordinated turning flight in horizontal plane, bank angle, load factor, V-n diagram; Minimum turn radius; Maximum sustained and attained turn rate; Turn in vertical plane, pull-up and pull-down manoeuvres. **High Lift Devices:** Different types of trailing edge flaps; Leading edge devices; Boundary layer control; Powered lift. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Aircraft Performance and Design", J.D. Anderson Jr., McGraw Hill	2000
2	. "Aircraft Performance", W.A. Mair & D.L. Birdsall, Cambridge University Press	2009
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Aircraft Performance", M. Saarlas, John Wiley & Sons	2007
2.	"Fundamentals of Flight", R.S. Shevell, Pearson Education Limited	2006
3.	"Airplane Aerodynamics and Performance", Jan Roskam & Chuan-Tau Edward Lan, DAR Corporation	2000
4.	"Aircraft Performance: An Engineering Approach", M.H. Sadraey, CRC Press	2017

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU2	**Aircraft Performance**	**C01**	To classify the different layer of atmosphere and its phenomina and calculate the aircraft different speed in different layer of atmosphere .
		C02	To explain the aerodynamics characteristics and steady level flight.
		C03	To explain the forces acting on flight vehicle in different flow region.
		C04	To analyze the steady level , climbing flight and explain the gliding flight, take-off and landing performance.
		C05	To illustrate the manoeuvring flight and high lift devices.

CO-PO MAPPING

Aircraft Performance	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	3	1								1		1		
	C02	3	3	2	3					1			1		
	C03	3	3	1	3					1		1	2		
	C04	2	3	1	2					2			1		
	C05	2	3		1				1						
	Average	**2.6**							**1**	**1.33**	**1**	**1**	**1.25**		

5ANU3: HEAT TRANSFER

B.TECH (Aeronautical) 5th semester

(3L+0T)

5ANU3	CONTENTS	HOURS
	Introduction: Definitions of heat and heat transfer, difference between heat transfer and thermodynamics; Basic modes and laws of heat transfer, engineering applications of heat transfer. **Conduction:** Fourier's law of heat conduction; Heat conduction equation for homogeneous isotropic materials in different coordinate systems, significance of thermal diffusivity. **Simple One-Dimensional Steady Heat Conduction Problems:** Plane wall temperature distribution and heat transfer, electrical analogy of heat transfer, composite walls, critical thickness of insulation; Steady one-dimensional heat conduction with heat generation; Analysis of fins having variable and constant cross-sectional area, fin efficiency and fin effectiveness. **Steady State Two-Dimensional Heat Conduction Problems (with no internal sources):** Heat conduction in a rectangular bar by method of separation of variables. **Unsteady Heat Conduction:** Definitions of lumped and distributed systems; Definition of Biot number and its physical implication, Biot number limit for lumped system. **Forced Convection:** Fundamentals, no-slip and no temperature-jump conditions, local and average heat transfer coefficients, Nusselt number; Forced convection over a flat plate, momentum and thermal boundary layer, Prandtl number and its range for various fluids. **Natural Convection:** Physical mechanism of natural convection; Steady laminar free convection from an isothermal vertical plate, similarity parameters, correlations of local and average Nusselt numbers, Grashof number.	

	Boiling: Pool boiling, saturated pool boiling curve, critical heat flux correlation, minimum heat flux and film boiling correlations. **Condensation:** Dropwise and film condensation; Nusselt's theory of laminar film condensation on a vertical plate. **Heat Exchangers:** Parallel flow & counterflow heat exchangers; Overall heat transfer coefficient, Fouling factor; LMTD, effectiveness of heat exchangers. **Thermal Radiation:** Radiation characteristics, Planck's law, Stefan-Boltzmann law, Wien's displacement law; Intensity of total and spectral radiation, relation to irradiation; Absorptivity, reflectivity and transmissivity, emissivity, definition of black, gray & diffuse surfaces; Kirchhoff's law; View Factor, reciprocity theorem, Fij for plane, convex and concave surfaces. **TOTAL**	**40**

	TEXT BOOKS	**Year**
1	"Principles of Heat Transfer", F. Kreith, R.M. Manglik & M.S. Bohn,	2001
2	"Principles of Heat and Mass Transfer", F.P. Incropera, D.P. Dewitt, T.L. Bergman & A.S. Lavine, Wiley India	2006
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Heat and Mass Transfer: Fundamentals and Applications", Y.A Cengel & A.J. Ghajar, McGraw-Hill Education	2017
2.	"Heat Transfer", J.P. Holman & S. Bhattacharyya, McGraw Hill Education	2016
3.	"Heat and Mass Transfer", P.K Nag, McGraw Hill Education	2006
4.	"Heat Transfer", P.S. Ghoshdastidar, Oxford University Press	2012

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU3	Heat Transfer	**C01**	Understand the modes of heat transfer.
		C02	Evaluate the performance factors to select the process and product of heat transfer.
		C03	Optimize the heat exchangers.
		C04	Demonstrate and examine the existing correlations.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Heat Transfer	**C01**	3	3	2	2										
	C02	3	3	3	3										
	C03	3	3	3	2										
	C04	2	3	3	2										
	Average	**2.75**	**3**	**2.75**	**2.25**										

5ANU4: ELEMENTS OF VIBRATION

B.TECH (Aeronautical) 5th semester

(3L+0T)

5ANU4	CONTENTS	HOURS
	Basics of Vibration: Scope of vibration, important terminology and classification; Degrees of freedom, harmonic motion; Vectorial representation, complex number representation. **Undamped Vibrations of Single Degree of Freedom System:** Derivation of equation of motion for one-dimensional longitudinal, transverse and torsional undamped free vibrations using Newton's second law; D' Alembert's principle and principle of conservation of energy; Compound pendulum and centre of percussion. **Damped Vibrations of Single Degree of Freedom System:** Viscous damping, underdamped, critically damped and overdamped systems, damping ratio, logarithmic decrement; Vibration characteristics of Coulomb damping and Hysteretic damping. **Forced Vibrations of Single Degree of Freedom System:** Forced vibration with constant harmonic excitation, steady state and transient parts; Frequency response curves and phase response curve; Forced vibration due to excitation of support. **System with Two Degrees of Freedom:** Principle mode of vibration, mode shapes; Undamped forced vibrations of two degrees of freedom system with harmonic excitation; Vibration absorber, undamped dynamic vibration absorber and centrifugal pendulum absorber. **Multiple Degree of Freedom Systems:** Exact analysis of undamped free vibrations; Approximate methods. **Vibrations of Continuous Systems:** Transverse vibration of a string; Longitudinal vibration of a bar; Torsional vibration of a shaft and flexural vibrations of a beam.	
	TEXT BOOKS	**Year**
1	"Mechanical Vibrations", S.S Rao, Pearson Education	2018
2	"Elements of Vibration Analysis", L. Meirovitch, McGraw-Hill	1975

	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Mechanical Vibrations", R. Venkatachalam, Prentice Hall India Learning Private Limited	**2014**
2.	"Mechanical Vibrations: Theory and Applications", Kelly, S.G., Cengage Learning	**2011**
3.	"Theory of Vibrations with Applications", W.T. Thomson, M.D. Dahleh & C. Padmanabhan, Pearson Education	**2008**
4.	"Principles of Vibration", B.H Tongue, Oxford Publication	**2002**

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU4	**Elements of Vibration**	**C01**	Explain the concept and types of vibration.
		C02	Determine the natural frequencies and mode shapes of the vibrating system.
		C03	Solve the equations of motion for multidegree-of-freedom systems.
		C04	Determine the natural frequency of continuous systems of free-vibration.
		C05	Identify the effects of vibrations on aircraft structures and the static and dynamic aeroelastic effects.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Elements of Vibration	**C01**	3	2	1			1							2	
	C02	3	2	1										2	
	C03	3	3	2										2	
	C04	3	3	2	1									2	
	C05	3	3	3	1	1								2	
	Average	**3**	**2.6**	**1.8**	**1**	1	**1**							**2**	

5ANU5: AIRCRAFT SYSTEMS

B.TECH (Aeronautical) 5th semester

(3L+0T)

5ANU5	CONTENTS	HOURS
	Airplane Control Systems: Conventional systems; Power-assisted and fully-powered flight controls; Push-pull rod system,flexible push-pull rod system components; Modern control systems, digital fly-by-wire systems, autopilot system technology; Introduction to communication and navigation systems; Instrument landing systems. **Hydraulic Systems:** Components; Hydraulic system controllers, modes of operation; Pneumatic systems, components, working principles and advantages. **Landing Gear Systems:** Classification, shock absorbers, retractive mechanism; Anti-skid system, wheels and brake, steering systems, indications. **Fuel Systems:** Types of fuels, their properties and testing, colour codes, fuel requirements; Pumps, fuel transfer systems, fuel tanks, plumbing, valves, indications and warnings; Aircraft fuel dumping/ jettison system. **Auxiliary System:** Various types systems, components and operation of air-conditioning system; Pressurization system; Oxygen systems; Fire protection systems; De-icing and anti-icing systems; Seat safety system: Ejection seats, survival packs, parachutes, pilot's personal equipment, doors, windows, emergency exits and seat belts. **General Maintenance Practices:** Jacking, levelling and mooring, refuelling and defueling of aircraft, safety precautions; Hydraulic and fluid systems precautions against contamination; Identification colour coding, symbols and other markings to identify the fluid systems.	
	TEXT BOOKS	**Year**
1	"Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", I. Moir & A. Seabridge, Wiley-	2011

2	"Aircraft Systems", D.A. Lombardo, McGraw Hill	2009
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	"Aircraft Instruments", E.H.J. Pallett, Pearson Education	2009
2.	"Aircraft Instrumentation and Systems", S. Nagabhushana, I.K. International Private Limited	2010
3.	"Aircraft Structures and Systems", Ray Wilkinson, Mechaero Publishing	2009
4.	"Aircraft Display Systems", M. Jukes, AIAA	2004

COURSE OUTCOME

Course Code	**Course Name**	**Course Outcome**	**Detail**
5ANU5	**Aircraft Systems**	**C01**	The student will understand the basic systems operated by fuel, hydraulic, landing and pneumatic power.
		C02	The student will know about the various control systems and will be able to select and design appropriate control system based on optimum conditions.
		C03	The student will be able to design engine systems for better engine health monitoring and control.
		C04	The student will understand about the auxiliary systems of the aircraft and design them.
		C05	The student will understand the operation of various aircraft instruments and able to select appropriate instruments for aircrafts and to design new instruments

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Aircraft Systems	**C01**	3	1	1	1	1									
	C02	3	1	1	1	1									
	C03	3	1	1	1	1									
	C04	3	1	1	1	1									
	C05	3	1	1	1	1									
	Average	**3**	**1**	**1**	**1**	1									

5ANU6.1: ROTORCRAFT DYNAMICS

B.TECH (Aeronautical) 5th semester

(3L+0T)

5ANU6.1	CONTENTS	HOURS
	Introduction: Basic features and layout of different rotorcrafts, main rotor, gearbox, tail rotor, power plant to drive main and tail rotor; Generation of lift, geometry of the rotor, blade loading, effect of solidity, profile drag, compressibility etc.; Blade area required, number of blades, power losses, rotor efficiency; Flapping, feathering and lagging motions of rotor blade. **Rotor Aerodynamics in Vertical Flight:** Momentum theory for hover, vertical climb and vertical descent; Induced-velocity curve; Autorotation; Ground effect; Thrust approximation, ideal twist, blade mean lift coefficient, power approximation, tip losses. **Rotor Aerodynamics in Forward Flight:** Equivalence of flapping and feathering, asymmetry of lift; Momentum theory; Wake analysis; Blade element theory. **Performance:** Hover and vertical flight; Forward level flight; Climb in forward flight, maximum rate of climb; Optimum and maximum level speed; Rotor limit envelope and prediction of accurate performance; Low drag helicopter speculations; High altitude operation. **Helicopter Trim Analysis:** Helicopter trim in forward flight, longitudinal trim; Effect of tail plane on trim; Lateral control to trim; Fixed and adjustable stabilizers. **Dynamic Stability and Control**: Longitudinal equations of motion, longitudinal dynamic stability; Lateral dynamic stability; Auto-stabilization; Rotor control response; Differences between stability and control of airplane and helicopter **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Basic Helicopter Aerodynamics", J. Seddon, AIAA Series	2011
2	"Helicopter Dynamics", A.R.S. Bramwell, John Wiley and Sons	1976

	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1.	."Helicopter Performance, Stability and Control", R. W. Prouty, Krieger Publishing Company	**2002**
2.	"Principles of Helicopter Engineering", Jacob Shapiro, McGraw Hill	**1971**
3.	"The Helicopter and How It Flies", John Fay, Himalayan Books	**2017**

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU6.1	**Rotorcraft Dynamics**	**C01**	Estimate the performance of a helicopter using momentum theory.
		C02	Understand the blade element theory for hover and vertical flight.
		C03	Understand the blade element momentum theory for forward flight.
		C04	Analyze the blade response and trim condition of a helicopter rotor system.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Rotorcraft Dynamics	**C01**	3	3	2									3	**2**	
	C02	3	3	2									3	3	
	C03	3	3	3						**2**				3	
	C04	3	3	2	3	2								3	
	Average	**3**	**3**	**2.25**	**3**	**2**				**2**			**3**	**2.75**	

5ANU7: CAD LAB

B.TECH (Aeronautical) 5th semester

3P

5ANU7	CONTENTS
	Introduction and different features of the CAD Software (AutoDesk Inventor/ SolidWorks/ CATIA) • 2-D Drafting • 3-D modelling • Assembly modelling • Feature modification and manipulation • Detailing • Surface modelling

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU7	CAD Lab	**C01**	Develop and present the engineering drawings as per standards.
		C02	Construct assembly drawing of various machine mechanical systems.
		C03	: Develop the skills for drafting using CAD software.
		C04	Construct the orthographic views and solid models using the software.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
CAD Lab	**C01**	2	1												1
	C02	3	3												2
	C03	3	2	2		3									3
	C04	3	2	2		3									3
	Average	1.75	2	2		**3**									**2.25**

5ANU8: HEAT TRANSFER LAB

B.TECH (Aeronautical) 5th semester

3P

5ANU8	CONTENTS
	• To determine thermal conductivity of insulating powders • To determine thermal conductivity of a good conductor of heat (metal rod) • To determine the individual thermal conductivity of different lagging in a lagged pipe • To determine the total thermal conductivity and thermal resistance of the given compound resistance in series • To determine the heat transfer rate and temperature distribution for a pin fin • To determine the surface heat transfer coefficient for heated vertical cylinder in natural convection • To find the heat transfer coefficient in forced convection in a tube • To study and compare LMTD and effectiveness in parallel flow heat exchangers • To study and compare LMTD and effectiveness in counter flow heat exchangers • Determination of heat transfer coefficient in drop wise and filmwise condensation • To determine critical heat flux in saturated pool boiling • To measure the emissivity of the test plate surface • To determine Stefan Boltzmann constant of radiation heat transfer • To understand the importance and validity of engineering assumptions through lumped heat capacity method

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU8	Heat Transfer Lab	C01	Analyze basic principles of heat transfer for various heat transfer applications.
		C02	Evaluate and optimize the heat transfer systems.
		C03	Evaluate the performance of different heat exchangers.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Heat Transfer Lab	C01	3	3	3	3										
	C02	3	3	3	3										
	C03	3	3	3	3										
	Average	3	3	3	3										

5ANU9: ELEMENTS OF VIBRATION LAB

B.TECH (Aeronautical) 5th semester

3P

5ANU9	CONTENTS
	• To verify time period a simple pendulum • To determine radius of gyration of compound pendulum • To determine the radius of gyration of given bar by using bifilar suspension • To determine natural frequency of a spring mass system • To determine natural frequency of free torsional vibrations of single rotor system • To verify Dunkerley's rule • Performing the experiment to find out damping coefficient in case of free damped torsional vibration • To conduct experiment of trifilar suspension • Harmonic excitation of cantilever beam using electro-dynamic shaker and determination of resonant frequencies • Study of vibration measuring instruments

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU9		**C01**	Determine the radius of gyration of different systems.
		C02	Evaluate the cases of natural and forced vibration effects and develop the understanding of practical processes.
		C03	Know the effects of damping on vibration analysis.
		C04	Apply the knowledge of evaluating the frequency of systems involving various degree of freedom.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	2	1	-	1										
	C02	2	2	1	2										
	C03	2	2	1	2										
	C04	2	2	1	2										
	Average	**2**	**1.75**	**1**	**1.75**										

5ANU10: AIRCRAFT SYSTEM LAB

B.TECH (Aeronautical) 5th semester

3P

5ANU10	CONTENTS
	• Control system ‘rigging check’ procedure • Aircraft ‘symmetry check’ procedure • ‘Flow test’ to assess of filter element clogging • ‘Pressure test’ to assess hydraulic external/internal leakage • Functional test of hydraulic actuator for its proper operation, leakage and load test • ‘Pressure test’ procedure on fuel system components • ‘Brake torque load test’ on wheel brake unit • Maintenance and rectification of snags in pneumatic, hydraulic and fuel systems components and on aircraft • Functional test of fire detection system on aircraft • Functional test of aircraft pressurization system on aircraft • Functional test of aircraft landing gear retraction system and its relevant indications in the cockpit • Study of combustion chambers of various engines

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU10	Aircraft System Lab	**C01**	The student will understand the basic systems operated by fuel, hydraulic, landing and pneumatic power.
		C02	The student will know about the various control systems and will be able to select and design appropriate control system based on optimum conditions.
		C03	The student will be able to design engine systems for better engine health monitoring and control.
		C04	The student will understand about the auxiliary systems of the aircraft and design them.
		C05	The student will understand the operation of various aircraft instruments and able to select appropriate instruments for aircrafts and to design new instruments.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Aircraft System Lab	**C01**	3	1	1	1	1									
	C02	3	1	1	1	1									
	C03	3	1	1	1	1									
	C04	3	1	1	1	1									
	C05	3	1	1	1	1									
	Average	**3**	**1**	**1**	**1**	**1**									

5ANU11: PROFESSIONAL ETHICS & DISASTER MANAGEMENT

B.TECH (Aeronautical) 5th semester

3P

5ANU11	CONTENTS
	Human Values: Effect of technological growth and sustainable development; Profession and human values, values crisis in contemporary society; Nature of values, psychological values, societal values and aesthetic values, moral and ethical values. **Professional Ethics:** Professional and professionalism, professional accountability, the role of a professional, ethic and image of the profession; Engineering profession and ethics, technology and society, ethical obligations of engineering professionals; Roles of engineers in industry, society, nation and the world; Professional responsibilities, collegiality, loyalty, confidentially, conflict of interest, whistle blowing. **Disaster Management:** Understanding disasters and hazards related issues in society and environment, risk and vulnerability; Types of disasters, their occurrence/causes, impact and preventive measures. **Natural Disasters:** Hydro-meteorological based disasters like floods, flash flood, cloud burst, drought, cyclone, forest fires;Geological based disasters like earthquake, Tsunami, landslides, volcanic eruptions **Man-Made Disasters:** Chemical industrial hazards; Major power breakdowns; Traffic accidents; Fire hazards; Nuclear accidents; Disaster profile of Indian continent, case studies; Disaster management cycle and its components.

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
5ANU11	Professional Ethics & Disaster Management	**C01**	Identify the importance of human values, harmony and ethical behavior in real life situations.
		C02	Distinguish the ethical problems & role of engineers in industry.
		C03	Enhance the knowledge and understanding of the management including manmade disaster.
		C04	Create and implement information disaster prevention and recovery plan.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Professional Ethics & Disaster Management	C01	3	3	3	2	3	2	2	1	2	2	2	3		
	C02	3	2	3	2	2	2	2			1	2	2		
	C03	3	2	3	3	2	1	3		1	3	1	2		
	C04	3	3	3	2	2	1	1	1	2	2		1		
	Average	**3**	**2.5**	**3**	**2.25**	**2.25**	**1.5**	**2**	**1**	**1.67**	**2**	**1.6**	**2**		

5ANUDC: DISCIPLINE & EXTRA-CURRICULAR ACTIVITIES

B.TECH (Aeronautical) 4th semester

3P

4ANUDC	CONTENTS
	As per UD, RTU norms

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
3ANUDC	Discipline & Extra-Curricular Activities	**C01**	Recognize their strength and those of others to work towards a shared vision (leadership).
		C02	Develop and sustain healthy and meaningful relationships with others (Interpersonal skills).
		C03	Identify and address the needs of the community collaboratively to facilitate positive social change (Social Responsibility).
		C04	Generate innovations through experimentation with novel ideas, forms, and methods (Critical and creative thinking).
		C05	Act as a disciplined citizen with ethical and moral values.

CO-PO MAPPING

Discipline & Extra-Curricular Activities	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01						2	1	3	2	1		2		
	C02						2	1	2	3	3		1		
	C03						3	2	2	2	2		2		
	C04	3	2	2	2	2		1		2	1		2		
	C05						2	1	3	1	1		2		
	Average	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.3**	**1.2**	**2.5**	**2.0**	**1.6**		**1.8**		

6ANU1: AEROSPACE PROPULSION – I

6ANU1	CONTENTS	HOURS
	Fundamentals of Air-Breathing Engines: Review of thermodynamic principles, basic principles of propulsion; History of air-breathing engines; Different types of air-breathing engines, functions of different engine components; Engine-aircraft matching; Methods of thrust augmentation. **Inlets:** Internal flow and stall in subsonic inlets, boundary layer separation; Major features of external flow near a subsonic inlet; Diffuser performance; Supersonic inlets, starting problem in supersonic inlets, shock swallowing by variable area inlet or byoverspeeding aircraft. **Centrifugal Compressor:** Operating principle, conservation of angular momentum, applications, advantages and disadvantages; Stage dynamics, velocity diagrams, cascade efficiency, performance characteristics; Stall and surge. **Axial Flow Compressor:** Euler's turbo-machinery equations, velocity diagram analysis, cascade action;Multi-staging; Degree of reaction; Radial equilibrium; Flow problems, compressor efficiency. **Axial Flow Turbine:** Types of turbines, performance parameters; Blade design principles; Axial turbine stage, stage efficiency; Turbine Performance; Blade stresses, blade cooling; Turbine and compressor matching. **Nozzles:** Flow in isentropic nozzles, nozzle choking; Nozzle efficiency, losses in nozzles; Overexpanded and under expanded nozzles; Ejector and variable area nozzles; Thrust reversal. **TOTAL**	**40**
	TEXT BOOK	
1	**"**Gas Turbine Theory", H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen & P.V. Straznicky, Prentice Hall	2017
2	"Mechanics and Thermodynamics of Propulsion", P. Hill & C. Peterson, Pearson Education	1991
	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	**Year**
1	"Aircraft Propulsion", Saeed Farokhi, Wiley-Blackwell	1971
2	"Elements of Gas Turbine Propulsion", J.D. Mattingly, McGraw Hill Education	1996

3	"Fundamentals of Jet Propulsion with Applications", R.D. Flack, Cambridge University Press	2012
5	"Gas Turbine Propulsion", D.P. Mishra, Viva Books	2015

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU1	**Aerospace Propulsion – I**	**CO1**	Contrast different kinds of aircraft engines and estimate their overall performance.
		CO2	Explain the relation between area ratio and external deceleration ratio for diffuser and estimate flow properties for different inlet conditions.
		CO3	Understand thoroughly the principles of working of compressors and compute their performance characteristics.
		CO4	Describe the working and challenges of turbines and evaluate their performance.
		CO5	Discern the effect of different flow conditions in a nozzle and accordingly quantify its efficiency.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Aerospace Propulsion – I	**C01**	3	2	2				1						2	
	C02	3	3	2	1	1								3	2
	C03	3	3	2	2	1								3	2
	C04	3	3	2		1								3	2
	C05	3	3	2										3	
	Average	**3**	**2.8**	**2**	**1.5**	**1**		**1**						**2.8**	**2**

6ANU2 Aircraft Structures – II

(3L+1T)

6ANU2	CONTENTS	HOURS
	Unsymmetrical Bending: Bending stresses in beams of unsymmetrical sections, general, principal axis and neutral axis methods; Bending stresses in beams of symmetric section with skew loads. **Shear Flow in Open Sections:** Thin-walled beams, concept of shear flow, shear center; Shear flow distribution in symmetrical and unsymmetrical thin-walled sections. **Shear Flow in Closed Sections:** Bredt-Batho method, single and multi-cell structures; Shear flow in single and multi-cell under torsion, shear and bending; Shear center of closed sections. **Buckling of Thin Plates:** Rectangular sheets under compression, local buckling stress of thin-walled section; Thin-walled column strength, crippling strength estimation; Buckling of sheet-stiffener combination, effective width. **Stress Analysis in Wing and Fuselage:** Loads on an aircraft, V-n diagram, shear force and bending moment distribution for semi-cantilever and other types of wings and fuselage; Shear and bending moment distribution for cantilever and semi cantilever types of beams, thin-webbed beam with parallel and non-parallel flanges. **TOTAL**	**40**
	TEXT BOOK	
1	"Aircraft Structures for Engineering Students", T.M.G. Megson, Butterworth-Heinemann	2017
2	"Analysis and Design of Flight Vehicles Structures", E.H. Bruhn, Jacobs Publishing Inc.	1991
	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	**Year**

1	"Theory and Analysis of Flight Structures", R.M. Rivello, McGraw Hill	1971
2	"Aircraft Structures", D.J. Peery & J.J. Azar, McGraw Hill	1996
3	"Mechanics of Aircraft Structures", C.T. Sun, Wiley India Private Limited	2012
5	"Airframe Stress Analysis and Sizing", M.C. Niu, Adastra Engineering Center	2015

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU2	**Aircraft Structures – II**	**CO1**	To calculate the bending stress of various sections with different loading conditions
		CO2	To classify the concept of shear flow in a thin-walled open and closed section
		CO3	To evaluate the stress developed in single-cell and multicell sections under the different load
		CO4	To analyze the buckling of aircraft thin structural plates
		CO5	To describe the different loads acting on wing and fuselage structure

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Aircraft Structures – II	**C01**	3	2	2		3							3	3	
	C02	3	2	2	3				2				3	3	
	C03	3	2	1		3					3			3	
	C04	2	1		3								3	2	
	C05												2		
	Average														

6ANU3: Aircraft Stability and Control

(3L+1T)

6ANU3	CONTENTS	HOURS
	Introduction: Static stability, dynamic stability, longitudinal, lateral and directional stability; Equations of motion. **Longitudinal Static Stability and Control:** Contribution of wing, horizontal tail and fuselage to total moment, canard configuration, flying wing configuration; Stick-fixed neutral point and static margin, stick-free neutral point, determination of neutral point by flight test, maneuver point; Power contribution to stability, elevator power, elevator angle to trim, elevator hinge movement, stick force and stick gearing, stick force gradients, aerodynamic balancing. **Directional Static Stability and Control:** Vertical tail contribution, fuselage contribution, wing contribution, propeller effect; Rudder power, yaw damping; Rudder-fixed and rudder-free directional stability, asymmetric power, pedal forces, rudder lock. **Lateral Static Stability and Control:** Effect of wing location, sweep and dihedral, fuselage and vertical tail; Coupling between rolling and yawing moments; Adverse yaw effects; Aileron reversal; Lateral control power; Roll damping, directional divergence. **Dynamic Stability and Control:** Euler angles, Equations of motion, stability & control derivatives; Decoupling of longitudinal and lateral-directional dynamics; Longitudinal modes; Lateral-directional modes; Autorotation and spin; Control response, impulse and step response; Controllability and Observability; Optimal control. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Flight Stability and Automatic Control", R.C. Nelson, McGraw Hill Education."	1998
2	"Flight Dynamics Principles", M.V. Cook, John Wiley & Sons Inc."	2012
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1	"Performance, Stability, Dynamics and Control of Airplanes" , B.N. Pamadi, AIAA	2000
2	"Airplane Performance, Stability and Control", C.D. Perkins & R.E. Hage, John Wiley & Sons	1989
3	"Mechanics of Flight", R.H. Barnard, D.R. Philpott & A.C. Kermode, Prentice Hall	2003

4	"Mechanics of Flight", W.F. Phillips, John Wiley & Sons	2017
5	"Dynamics of Flight: Stability and Control", B. Etkin & L.D. Reid, John Wiley & Sons	2017

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU3	**Aircraft Stability and Control**	**C01**	To explain the different types of stability of aircraft
		C02	To calculate the longitudinal stability condition of different components of aircraft
		C03	To classify the directional stability and control
		C04	To examine the lateral statics stability of the different components of aircraft
		C05	To examine the different modes of aircraft in dynamics stability

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Aircraft Stability and Control	**C01**	3	2		3					2			3	3	2
	C02	3	2		3								2	3	2
	C03	3	3		3							3	1	3	3
	C04	3	1	2	2	3							3	3	1
	C05	3	1	3	1	3					3			3	1
	Average														

6ANU4 Space Dynamics

(3L+0T)

6ANU4	CONTENTS	HOURS
	Introduction: Definition of space, space environment, effect of space environment on materials of spacecraft structure; Solar system, celestial sphere, ecliptic, equatorial plane and equinoxes; History of space exploration, Space missions and role of launch vehicles and spacecraft, different types of earth orbits, types of space craft, spacecraft subsystems; Newton's law of gravitation, Kepler's laws; Vector differentiation, kinematics relative to rotating frames. **Two-body Problem:** Equation of relative motion, conservation of angular momentum and energy; Different types of trajectories, orbital elements; Lambert's theorem. **N-body Problem:** Equation of motion; Restricted three-body problem, Lagrangian points, concept of sphere of influence. **Orbital Manoeuvres:** Hohmann transfer, bielliptic transfer, plane change manoeuvres, combined manoeuvres, low thrust transfer manoeuvres, Non-coplanar transfer; Rendezvous missions, interplanetary trajectories, gravity assist trajectories; Orbit perturbations. **Rocket Vehicle Dynamics:** Basic functions and features of rockets and missiles; Tsiolkovsky rocket equation; Launch vehicle ascent trajectories and its different phases, effect of aerodynamic drag and gravity on ascent mission performance, vertical, inclined and gravity turn trajectories; Static and dynamic stability of rockets, rocket thrust vector control methods; Concept of multi-staging, series and parallel staging configurations, optimal staging solutions; Re-entry vehicles and missions, aerobraking. **Attitude Dynamics and Control:** Euler's equations for rotational dynamics; Torque-free motion of asymmetric and axisymmetric rigid bodies; Spinning and non-spinning spacecraft, dual spin spacecraft, effect of energy dissipation on stability of rotational motion, nature of attitude response to atmospheric disturbances; Overview of	

	actuation mechanisms for attitude control, gyroscopic motion, stabilization through gravity gradient, attitude sensors, design of control of three-axis stabilized spacecraft in orbit using reaction wheels, thrusters, magnets, single and double gimbaled control moment gyros, Yo-Yo mechanism.	
	TOTAL	**40**

	TEXT BOOKS	
1	"Orbital Mechanics for Engineering Students", H.D. Curtis, Butterworth-Heinemann	
2	"Elements of Space Technology", R.D. Meyer, Academic Press	
	REFERENCE BOOKS	
S.NO.	**Name of author/Book/publisher**	
1	"Orbital Mechanics", V.A. Chobotov, AIAA Education Series	
2	"Fundamentals of Astrodynamics", R.R. Bate, D.D. Mueller & J.E. White, Dover Books	
3	"Spaceflight Dynamics", W.E. Wiesel, Aphelion Press	
4	"Fundamentals of Astrodynamics and Applications", D.A. Vallado, J. Wertz, Microcosm Press 5. "Rocket and Spacecraft Propulsion", M.J.L. Turner, Springer	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU4	**Space Dynamics**	**C01**	To illustrate basic introduction of orbit, types of spacecraft, space environment and forces acting on spacecraft
		C02	To solve the two-body and n-body problem
		C03	To classify the orbital maneouvers
		C04	To articulate the rocket vehicle dynamics

		C05	To predict the attitude dynamics and control of spacecraft

CO-PO MAPPING

Space Dynamics	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	3	1		3						1		1	3	1
	C02	2	1		3					1	1			2	1
	C03	3	3	1	2		1					1	1	3	3
	C04	2	1	1	3					1				2	1
	C05	3	2	1	3								2	3	2
	Average														

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6ANU5 Mechanics of Composites

(3L+0T)

6ANU5	CONTENTS	HOURS
	Fundamentals of Composite materials: Definition, matrix & fibres, various types of matrix materials and their properties, properties of various type of fibres like glass, Kevlar, carbon and graphite; Polymers, properties of polymers like epoxy, polyester and phenolic; Applications of composites with emphasis on aerospace industry. **Manufacturing of Composites:** Hand lay-up technique; Autoclave moulding; Pressure bag and vacuum bag moulding; Pultrusion; Resin-transfer moulding; Injection moulding; Bulk and sheet moulding compound methods; Prepregs. **Elastic Behaviour of Composite Lamina-Micromechanics:** Volume fraction, weight fraction, density of composites; Micromechanics and Macromechanics approach; Longitudinal elastic properties, transverse elastic properties, in-plane shear modulus, Poisson's ratio, Halpin-Tsai equations. **Elastic behaviour of Composite Lamina-Macromechanics:** Stress-Strain relations, general anisotropic materials, orthotropic material, transversely isotropic material, isotropic material; Stress-strain relations for a thin lamina. **Analysis of multidirectional Laminates:** Laminate orientation code, symmetric and balanced laminate; Introduction to cross ply, angle-ply and quasi-isotropic laminates; Classical laminate theory, strain-displacement relationship, stress-strain relations, force and moment resultants, in-plane and flexural laminate stiffness; Asymmetric laminate and coupling effect; Stress analysis of cross-ply symmetric laminate under in-plane and flexural loading. **Special Types of Composites:** Short fiber composites; Sandwich structure composites; Honeycomb structure. **Mechanical Testing of Composites:** Tensile testing; Compressive testing; Intra-laminar shear testing; Fracture testing; Impact testing; Fatigue testing.	

	Failure and Maintenance of Composites: Failure types in laminates; Damage to laminate structures; Inspection methodology, quality control. **TOTAL**	**40**
	TEXT BOOKS	
1	"Analysis and Performance of Fiber Composites", B.D. Agarwal & L.J. Broutman, John Wiley & Sons	2003
2	"Engineering Mechanics of Composite Materials", I.M. Daniel & O. Ishaai, Oxford University Press	2014
	REFERENCE BOOKS	
S.NO.	**Name of author/Book/publisher**	**Year**
1	"Mechanics and Analysis of Composite Materials", V.V. Vasiliev & E.V. Morozov, Elsevier Science Ltd.	2008
2	"Mechanics of Composite Materials", R.M. Jones, Taylor and Francis	1957
3	"Principles of Composite Material Mechanics", Ronald F. Gibson, CRC Press	2002
4	"Mechanics of Composite Materials", Autar K. Kaw, Taylor and Francis	2013
5	"Composite Material: Science and Engineering", K.K. Chawla, Springer-Verlag New York Inc.	2019

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU5	**Mechanics of Composites**	**C01**	Some understanding of types, manufacturing processes, and applications of composite materials
		C02	Ability to solve and analyze problems on micromechanical behavior of lamina
		C03	Ability to solve and analyze problems on macro mechanical behavior of composites
		C04	To determine stresses and strains in composites.

		C05	Apply constitutive equations of composite materials and understand mechanical behavior.

CO-PO MAPPING

Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
C01	2	3	2	2	2				2			2		
C02	3	3	2	2	3				2			1		
C03	2	2	1	2	2				1			2		
C04	3	3	2	2	3				2			1		
C05	3	3	2	2	2				2			2		
Average														

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6ANU6.1: UNMANNED AERIAL VEHICLES

(3L+0T)

6ANU6.1	CONTENTS	HOURS
	Introduction: History, classification and applications of UAVs; Unmanned Aircraft System (UAS), UAS composition, societal impact, future prospects; Regulations and safety considerations. **Characteristics of UAV Types:** Long-range, long-endurance, MUAV types, MAV and NAV types, UCAV, Novel hybrid aircraft configurations. **UAV Propulsion:** Internal combustion engines; Turbine engines; Electrical systems. **Aerodynamics:** Low Reynolds number effects; Lift-induced drag, parasite drag; Rotary wing aerodynamics; Response to air turbulence; Dynamic stall. **Control and Stability:** Flight control of HTOL aircraft, helicopters, convertible rotor aircraft; Autopilot systems & ground control station; Sensors used in UAVs; On-board flight control **Introduction to Design and Selection of UAV:** Conceptual design, preliminary design, detailed design, selection of UAV for particular requirement. **Aspects of Airframe Design:** Airframe configuration, scale effects, packaging density; Aerodynamic design; Strength, stiffness and reliability requirements; Flight and gust envelopes including manoeuvre loads; Selection of power plants; Design for stealth. **Payload Types:** Non-dispensable and dispensable payloads, sensing/surveillance, weaponized, delivery. **Communications:** Communication media, radio communication, mid-air collision avoidance system, communication data range and bandwidth usage, antenna types, telemetry. **Navigation:** NAVSTAR-GPS, TACAN, LORAN-C, inertial navigation, radio tracking. **TOTAL**	**40**
	TEXT BOOK	

1	"Unmanned Aircraft Systems: UAVS Design, Development and Deployment", Reg Austin, Wiley	
2	"Introduction to Unmanned Aircraft Systems", D.M. Marshall, R.K. Barnhart, E. Shappee & M.T. Most, CRC Press	
	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	
1	"Small Unmanned Aircraft: Theory and Practice", R.W. Beard & T.W. McLain, Princeton University Press	
2	"Unmanned Aircraft Systems", E. Atkins, A. Ollero & A. Tsourdos, John Wiley & Sons	
3	"Introduction to UAV Systems", P. Fahlstrom & T. Gleason, Wiley	
4	"Theory, Design, and Applications of Unmanned Aerial Vehicles", A.R. Jha, CRC Press	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU6.1	**Unmanned Aerial Vehicles**	**CO1**	Discuss the configuration, performance parameters, and design aspects of unmanned aerial vehicle (UAV).
		CO2	Compare the sensors, payloads and actuators suitable for various UAVs.
		CO3	Explain the working of UAV propulsion systems.
		CO4	Discuss the communication and navigation systems in UAV
		CO5	Explain the practical limitations in the design and development of an UAV

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO 2
Unmanned Aerial	**C01**	S	-	W	-	-	-	-	-	-	-	-	-	M	

	C02	M	-	-	-	-	-	-	-	-	-	-	-	S	
	C03	W	-	-	-	-	-	-	-	-	-	-	-	W	
	C04	M	-	-	-	-	-	-	-	-	-	-	-	W	
	C05	-	-	W	-	-	-	S	-	-	-	-	-	W	
	Average														

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6ANU7: AEROSPACE PROPULSION LAB

(3L+0T)

6ANU7	CONTENTS	HOURS
	• Study of an aircraft piston engine (includes study of assembly of subsystems, various components, their functions and operating principles) • Study of an aircraft jet engine (includes study of assembly of subsystems, various components, their functions and operating principles) • Scrutiny of the constructional details of combustion chamber • Analysis of performance of a propeller • Characterization of intake • Experiment on axial compressor (flow fan) test rig • Study of an aircraft computerized gas turbine • Ignition studies of solid and liquid propellants • Understanding operation of a ramjet engine • Measurement of nozzle flow • Cascade testing of a model of axial compressor and turbine blade row • Flame stabilization in continuous combustion unit • Burning rate measurement of solid propellants in a strand burner • Description of constructional details of afterburning system.	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU7	Aerospace Propulsion Lab	C01	**Understand the basics of propulsion, working principles of reciprocating engines, performance estimation based on rotation angles, and components of engine and their functions**
		C02	Understand the basic characteristics and range of performance of axial flow gas turbine. Perform parametric jet engine performance analysis and turbo machinery and basic combustion calculations
		C03	Teach physical working of turbo machinery components and related pressure calculations

		C04	Give practical exposure on working of nozzle and its performance calculations
		C05	Explain actual working of gas turbine combustion and associated combustion mechanism different advanced propulsion systems.

CO-PO MAPPING

Aerospace Propulsion Lab	**Course Outcome**	**P01**	**P02**	**P03**	**P04**	**P05**	**P06**	**P07**	**P08**	**P09**	**P10**	**P11**	**P12**	**PSO1**	**PSO2**
	C01	S	M	S					S				S	S	
	C02	S	S	S	W		S			S			M	M	
	C03	S	M	M									M	M	
	C04	S	S	M		M							S	S	
	C05	S	S	M					M				S	S	
	Average														

6ANU8 Aeromodelling Design and Fabrication lab

(3L+0T)

6ANU8	Aeromodelling Design and Fabrication lab	HOURS
	• Design and fabrication of fixed-wing gliders • Comparison of properties of thermocole, balsa wood, Styrofoam, composites for aeromodel fabrication Detailed design of fixed-wing powered aeromodels • Design, fabrication and testing of different components • Aerodynamic and structural design • Use of flight simulator to practise flying aeromodels • Concepts used in unconventional UAVs such as rotary wing models and ornithopters **TOTAL**	**40**

COURSE OUTCOME

Course code	Course Name	Course Outcome	Detail
6ANU2	Aeromodelling Design and Fabrication lab	C01	Demonstrate the working principal of fixed-wing gliders.
		C02	Know wood crafting and the technology of new materials
		C03	Understand aerodynamics, designing, electronics and technology
		C04	Design, fabricate and fly models
		CO5	Discuss the autopilot systems in aircraft.

CO-PO MAPPING

Aeromodelling Design and	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	S	S	-	S	-	M	-	-	-	-	-	M	M	
	C02	S	S	W	S	-	M	-	-	-	-	-	M	M	

	C03	M	M	-	S	-	M	-	-	-	-	-	S	W	
	C04	M	S	-	S	-	-	-	-	-	-	-	S	W	
	C05														
	Average														

6ANU9 Advanced Programming in MATLAB

(3L+0T)

6ANU9	CONTENTS	HOURS
	• Basics of MATLAB computer programming • Use of formulae and inbuilt functions • MATLAB scripts and functions (m-files) • Loops and nested loops • Array, vector and matrices • Plotting functions and vector plots • Solving differential equations using MATLAB • Reading and writing data, file handling • Using MATLAB toolboxes • MATLAB graphic functions.	

	TEXT BOOKS	
1	"Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers", R. Pratap, Oxford	
2	"MATLAB for Beginners: A Gentle Approach", P.I. Kattan, P.I. Kattan	
	REFERENCE BOOKS	
S.NO.	**Name of author/Book/publisher**	
1	"MATLAB For Dummies", J. Sizemore, John Wiley & Sons	
2	"Modeling and Simulation using MATLAB – Simulink", S. Jain, Wiley	
3	"MATLAB Programming for Engineers", S.J. Chapman, Cengage	
4	"Essential MATLAB for Engineers and Scientists", B. Hahn, D.T. Valentine, Academic Press 5. "MATLAB: An Introduction with Applications", A. Gilet, Wiley	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU9	Adv an	**C01**	To classify the basic concepts of MATLAB.

		C02	To develop loops, branching, control instruction and functions in MATLAB programming environment.
		C03	To Analyze different types of graphs of different mathematical models.
		C04	To Apply many built in functions in MATLAB to solve numerical problems.
		C05	To develop code for solving problems involving different types of mathematical models and differential equations

CO-PO MAPPING

Advanced Programming in MATLAB	**Course Outcome**	**P01**	**P02**	**P03**	**P04**	**P05**	**P06**	**P07**	**P08**	**P09**	**P10**	**P11**	**P12**	**PSO1**	**PSO2**
	C01	3	2	1	3						1		1	3	2
	C02	2	3			2				1			2	2	3
	C03	3	1								1		1	3	1
	C04	2	3	1		1					1		2	2	3
	C05	1	3	1		1			1				1	1	3
	Average														

6ANU10 Mechatronics Lab

(3L+0T)

6ANU 10	Mechatronics Lab	HOURS
	• Introduction to the concept of Mechatronics and its applications • Study of different types of sensors and transducers • Introduction to Arduino IDE and its basic commands • Introduction to programming in LabVIEW • Use of LabVIEW for data acquisition • Variation of blink rate and brightness of LEDs • Using servo motor as an actuator to move to specified position • Speed control of stepper motor • Use of relay as conditional switch • Use of strain guage sensor for measuring loads • Temperature measurement using thermocouple • Measurement of pressure using data acquisition system Introduction to Simulink **TOTAL**	**40**

COURSE OUTCOME

Course code	Course Name	Course Outcome	Detail
6ANU10	Mechatronics Lab	**C01**	Understand use of different kinds of sensors and actuators
		C02	Learn writing simple codes in Arduino IDE
		C03	Familiarize with basics of LabVIEW program and its components such as front panel and block diagram
		C04	Learn how to use basic sensors and actuators like LEDs, buzzer, motors.
		CO5	Measure load, displacement and temperature using analogue and digital sensors.

CO-PO MAPPING

Mechatronics Lab	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	3	1	2		3							2		
	C02	3	3	3	2	3							2		
	C03	2	3	3	2	3							2		
	C04	3	3	3	2	3							2		
	C05	3	2	2	2	3							2		
	Average														

6ANU11 Business Communication Lab

(3L+0T)

6ANU 11	Business Communication Lab	HOURS
	Introduction: Process of communication, importance of communication in business; Differences between technical and general communication; Barriers to communication and measures to overcome them. **Language for Communication:** Language and communication; Essentials of good style, expressions and words to be avoided, grammar and usage. **Listening Skills:** Importance of Listening, barriers to listening, strategies for effective listening, listening in a business context. **Oratory Skills:** Structure of different types of business speeches, public speaking, voice modulation; Quotations by prominent business personalities; Practice of appreciation, motivation, criticism. **Internal Business Communication:** Guidelines for attending meetings, common mistakes made at meetings; Writing memos, circulars and notices, important guidelines. **External Business Communication:** Writing business letters, importance of business letters, difference between personal and business letters; Types of business letters, structure and format of business letters and important their features such as style, effectiveness, promptness; Communication with media through news releases and advertisements. **E-mail Writing:** Communication through e-mail, e-mail etiquette; Overcoming problems in e-mail communication. **Body Language:** Importance of body language; Appropriate body postures in standing or sitting position, body movements during presentations and speeches, gestures, facial expressions, eye movements in response to different situations; Video samples. **Presentation Skills:** Importance of giving presentations, presentation skills, use of visual aids such as handouts, transparencies and presentation software, features of a good presentation; Video conferencing.	

	Technical Report Writing: Types of reports and different formats, purpose of report writing; Structure of report; Features of effective writing such as clarity, brevity, appropriate tone, balance etc.; Synopsis and thesis writing. **Employment Communication:** Preparing resume, contents of good resume, guidelines for writing resume, different types of resumes; Writing cover letter; Group discussion skills; Interview skills, manners and etiquettes to be maintained during an interview, sample questions commonly asked during interview. **TOTAL**	**40**

	TEXT BOOKS	
1	"Business Communication: Process and Product", M.E. Guffey & D. Loewy, Cengage Learning	
2	"Business Communication: Making Connections in a Digital World", R. Lesikar, M.E. Flatley & K. Rentz, McGraw-	
	REFERENCE BOOKS	
S.NO.	**Name of author/Book/publisher**	
1	"Business Communication: Developing Leaders for a Networked World", P. Cardon, McGraw-Hill Education	
2	"Basic Communication Skills for Technology", A.J. Rutherfoord, Pearson	
3	"Essentials of Business Communication", R. Pal & J.S. Korlhalli - Sultan Chand & Sons	
4	"Business Communication: Skills, Concepts, and Applications", P.D. Chaturvedi & M. Chaturvedi, Pearson India	

COURSE OUTCOME

Course code	Course Name	Course Outcome	Detail
6ANU11	Business Communication Lab	C01	Explain the basic terminologies of business communication.
		C02	Collect the pattern of different business letters and formats used in written communications
		C03	Discover semantics and body language relevant to business communication.
		C04	Examine englisg accent and pronunciation of commonly used English words.
		CO5	Communicate effectively while handling telephonic interviews, participating in GD and during public speaking

CO-PO MAPPING

Business Communication Lab	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01		3	1	1	1	3	1	3	2	3	3	3		
	C02		2	1	1	1	2	2	3	2	3	3	3		
	C03						1	1	2	2	3	2	3		
	C04		1	1	3	1	1	1	3	2	3	3	3		
	C05		1	1	1	1	1	1	3	2	3	3	3		
	Average		1.8	1	1.5	1	1.6	1.2	2.8	2	3	2.8	3		

7ANU1: Aerospace Propulsion – II

7ANU1	Aerospace Propulsion – II	HOURS

	Propeller Theory: Momentum theory, blade element theory, combined blade element and momentum theory, propeller power losses, propeller performance parameters. **Fundamentals of Combustion:** Thermochemistry, stoichiometric ratio and mixture ratio, energy release during combustion, heat of formation, heat of combustion, stoichiometric reaction; Adiabatic flame temperature, flammability and stability limits; Premixed and diffusion flames; Chemical equilibrium, chemical kinetics, reacting flow, frozen flow. **Gas Turbine Combustors:** Types of aviation fuels; Classification of combustion chambers, important factors affecting combustion chamber design; Combustion process; Combustion chamber performance; Ignition and engine starting; Flame tube cooling; Flame stabilization; Afterburners, supercharging. **Ramjet Propulsion:** Operating principle of ramjet propulsion, types of ram propulsion; Efficiencies of different components; Critical, subcritical and supercritical modes of combustion; Need for supersonic combustion for hypersonic propulsion, salient features of scramjet engine and its applications for hypersonic vehicles, problems associated with supersonic combustion. **Rocket Propulsion:** Brief history and principle of rocket; Rocket equation; Classification of rockets, mass ratio of rocket; Solid propellant rockets, estimation of solid propellant adiabatic flame temperature; Salient features of liquid propellant rockets, selection of liquid propellants, thrust control in liquid rockets, cooling in liquid rockets; Hybrid rocket propulsion; Rocket nozzles, conical nozzle and contour nozzle, under and over expanded nozzles, flow separation in nozzles, unconventional nozzles; Nozzle performance, nozzle area ratio, mass flow rate, characteristic velocity; Thrust coefficient, performance parameters; Staging and clustering. **Advanced Propulsion Techniques:** Arc jet, Resisto jet; Hall effect thrusters; Electric rocket propulsion; Ion propulsion techniques; Nuclear rocket; Solar sail; Preliminary Concepts in nozzleless propulsion; Thrust reverser; Stealth technology. **TOTAL**	**40**
	TEXT BOOK	
1	"Rocket Propulsion Elements", G.P. Sutton & O. Biblarz, John Wiley & Sons	
2	"Theory of Aerospace Propulsion", P.M. Sforza, Butterworth-Heinemann	
	REFERENCE BOOK	

S.NO.	Name of author/Book/publisher	
1	"Aerospace Propulsion System", T.A. Ward, Wiley	
2	"Aerospace Propulsion", T.W. Lee, Wiley-Blackwell	
3	"Aircraft Engines and Gas Turbines", J.L. Kerrebrock, The MIT Press	
5	"Aircraft Propulsion and Gas Turbine Engines", A.F. El-Sayed, CRC Press	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
7ANU1	Aerospace Propulsion – I	CO1	Understand the fundamentals of propeller engine and their design parameter and performance.
		CO2	Basic concept of combustion process and determine the various condition for combustion stability
		CO3	Evaluate various type of aviation fuels and their merits and demerits
		CO4	Evaluate various type of aviation fuels and their merits and demerits
		CO5	Basic principle of Ramjet engine and their performance parameters.

CO-PO MAPPING

Aerospace Propulsion – I	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	S	M											S	
	C02	S		S						M			W	M	
	C03	S	M										S	M	
	C04	S	M										S	S	
	C05	M	M	S						M				S	
	Average														

7ANU2 AIRCRAFT DESIGN

(3L+1T)

7ANU2	CONTENTS	HOURS
	Aircraft Design Fundamentals: Introduction to design, engineering design, feasibility analysis, review, evaluation, and feedback; Conceptual system design, preliminary system design, detail system design; Aircraft design requirements and specifications, airworthiness, aerodynamic and structural design considerations; UAV design. **Aircraft Conceptual Design:** Aircraft configuration alternatives, aircraft classification and design constraints; Configuration selection process and trade-off analysis; Material selection; Conceptual design optimization. **Preliminary Design:** Maximum Take-Off Weight Estimation; Estimation of cruise and manoeuvring loads; Load factor, v-n diagram; Wing loading, wing area; Engine sizing. **Wing Design:** Factors influencing selection of airfoil and planform; Spanwise load distribution, Stalling, take-off and landing considerations; Bending moment and shear force; Selection of wing vertical location, airfoil section, wing incidence, aspect ratio, taper ratio, sweep angle, twist angle, dihedral angle, high-lift device; Estimation of wing drag. **Tail Design:** Aircraft trim requirements; Tail configuration, canard or aft tail; Optimum tail arm; horizontal tail parameters; Vertical tail design. **Fuselage Design:** Fuselage configuration design and internal arrangement; Cockpit design; Passenger cabin design; Cargo section design; Other fuselage internal segments; Optimum length-to-diameter ratio; Lofting. **Propulsion System Design:** Functional analysis and design requirements; Selection of type of engine, number of engines, engine location; Engine installation; Propeller sizing; Engine performance. **Landing Gear Design:** Functional analysis and design requirements; Selection of landing gear configuration, possible retraction mechanism into fuselage or wing; Landing Gear position according to aircraft centre of gravity; Absorption of landing loads. **Design of Control Surfaces:** Aileron Design, Elevator Design, Rudder Design.	

	Weight Calculation: Estimation of weight of major components, Aircraft weight distribution; Aircraft centre of gravity calculation, centre of gravity range; Aircraft mass moment of inertia. **Advanced Design Concepts:** Supersonic aircraft design; Very large aircraft; Morphing aircraft; Supercritical wing; Relaxed stability; Flying wing, tailless, lifting fuselage, and blended wing-body designs; Special considerations such as stealth, maintainability etc. **Complete Design Problem:** Design of airframe for given specifications with constraints; Prediction of performance, stability and control, range-payload diagram, v-n diagram, noise and emission levels, life cycle cost; Reviewing selection of engines from all considerations; Freezing the design; Preparation of preliminary drawings including 3 views and layout. **TOTAL**	**40**
	TEXT BOOK	
1	"Aircraft Design: A Conceptual Approach", D.P. Raymer, AIAA Education Series	
2	"Aircraft Design: A Systems Engineering Approach", M. H. Sadraey, Wiley-Blackwell	
	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	
1	"Aircraft Design", A.K. Kundu, Cambridge University Press	
2	"Introduction to Aircraft Design", J.P. Fielding, Cambridge India	
3	"General Aviation Aircraft Design: Applied Methods and Procedures", S. Gudmundsson, Butterworth-Heinemann	
4	"Design of Aircraft", T.C. Corke, Pearson	
5	"Advanced Aircraft Design: Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes", E. Torenbeek, Wiley-Blackwell	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
7ANU2	Aircraft Design	**CO1**	To distinguish aircraft design fundamental and conceptual design
		CO2	To illustrate aircraft preliminary design
		CO3	To estimate the different parameter of aircraft components
		CO4	To develop the landing gear design and control surfaces
		CO5	To Calculate the aircraft center of gtavity and devlop the detail aircraft design

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P010	P011	P012
Aircraft Design	**C01**	3	1	3	2						1		1
	C02	3	3	3	2	2		1		2	1		
	C03	3	3	2	3				1				1
	C04	3	2	2	3			1		2		1	
	C05	3	2	2			2				1		2
	Average												

7ANU3: Introduction to Computational Fluid Dynamics

(3L+1T)

7ANU3	Introduction to Computational Fluid Dynamics	HOURS
	Introduction: Importance and applications of CFD in diverse fields; Different types of partial differential equations — hyperbolic, parabolic, elliptic and mixed types; Fundamental concept of CFD. **Governing equations:** Continuity, momentum and energy equations in conservative and non-conservative forms; Governing equations in boundary layers and inviscid flows; Initial and boundary conditions. **Discretization:** Concept and need of discretization of differential equations; Different discretization techniques — finite difference, finite element and finite volume methods and their comparison; Fundamentals of FDM, forward, backward and central difference, ADI scheme, applications to simple problems such as transient one-dimensional and two-dimensional conduction; Stability criterion, errors, consistency, optimum step size. **Grid generation:** Types of grid; Structured, unstructured and hybrid mesh in 2d & 3d, their relative merits and regions of application; Coordinate transformation; Elliptic grid generation; Grid independence test; Adaptive grids, modern developments in grid generation. **Calculation of flow field:** Methods of solution, simple 1d computations using different methods; Convergence criterion; Implicit and explicit algorithms; Pressure and velocity corrections; Vorticity-streamfunction method; Solution of turbulent flows and turbulence modelling. **TOTAL**	**40**
	TEXT BOOKS	**Year**
1	"Computational Fluid Dynamics – The Basics with Applications", J. D. Anderson Jr., McGraw-Hill	1998
2	"Computational Fluid Flow and Heat Transfer", K. Muralidhar & T. Sundarajan, Narosa Publishing House	2012
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	**Year**
1	"Numerical Computation of Internal and External Flows", C. Hirsch, Butterworth-Heinemann	2000
2	"Fundamentals of Engineering Numerical Analysis", P. Moin, Cambridge University Press	1989

3	"Numerical Methods for Engineering Application", J. H. Ferziger, Wiley	2003
4	"Computational Methods for Fluid Dynamics", J. H. Ferziger & M. Peric, Springer	2017
5	"Computational Fluid Dynamics", T.J. Chung, Cambridge University Press	2017

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
7ANU3	**Introduction to Computational Fluid Dynamics**	**C01**	Ascertain basic concepts in the fluid mechanics
		C02	Analyze practical complications of fluid flow
		C03	Design incompressible flow components used in fluid machines and air- conditioning
		C04	Understand the performance of fluid flow devices in laminar and turbulent flows
		C05	Apply the concepts in the analysis of fluid flow problems

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Introduction to Computational Fluid	**C01**	3	3	2	3										
	C02	3	3	3	2	3		2	2				2		
	C03	2	3	2	2	3			3				2		
	C04	3	2	3	2	3		**2**	**2**	**1**			**2**		
	C05	2	2	2	2	2		**2**	**2**	**1**			**2**		
	Average	**2.6**	**2.6**	**2.4**	**2.2**	**2.8**		**2**	**2.3**	**1**			**2**		

7ANU4 Finite Element Method

(3L+0T)

7ANU4	CONTENTS	HOURS
	Introduction and Review of Mathematics: Introduction to FEM and its applications; Advantages of FEM, comparison with other methods such as FDM and FVM; Review of matrix algebra, Gauss elimination method, banded symmetric matrix and bandwidth. **Discretization:** Geometrical approximations, Element shapes and behaviour, Choice of element types, size and number of elements, Location of nodes; p and h method of mesh refinement; Shape functions and their properties; Assembly and boundary conditions. **Finite Element Formulation from Governing Differential Equations:** General field problems, discrete and continuous models; Method of weighted residuals; Galerkin's method and other methods; Introduction to variational formulation (Ritz technique); Convergence of solution, compatibility. **One-Dimensional Finite Element Analysis:** One-dimensional second order equation, derivation of shape functions, Stiffness matrix and force vectors, assembly of elemental matrices, Derivation of finite elements equations using potential energy approach, 1-D bar element; longitudinal vibration and mode shapes, fourth order beam equation, transverse deflections and natural frequencies, solution of problems from fluid mechanics and heat transfer.	
	TOTAL	**40**

	TEXT BOOKS	
1	"Fundamental of Finite Element Analysis", D.V. Hutton, McGraw Hill Education	
2	"Text Book of Finite Element Analysis", P. Seshu, Prentice Hall India	
	REFERENCE BOOKS	

S.NO.	Name of author/Book/publisher	
1	"An Introduction to the Finite Element Method", J.N. Reddy, McGraw-Hill	
2	"Finite Element Procedure in Engineering Analysis", K.J. Bathe, Prentice Hall India	
3	"Introduction to Finite Elements in Engineering", T.R. Chandrupatla & A.D. Belegundu, Prentice Hall of India	
4	"Applied Finite Element Analysis", L.J. Segerlind, John Wiley & Sons	
5	"Concepts and Applications of Finite Element Analysis", R.D. Cook, D.S. Malcus, M.E. Plesha & R.J. Witt, John Wiley & Sons	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
7ANU4	Finite Element Method	C01	Realize the significance and applications of finite element method
		C02	Formulate and solve one-dimensional structural problems using linear and quadratic elements and explain concept of shape function & its properties.
		C03	Analyze plane stress and plane strain problems using CST elements
		C04	Use FEM to solve simple fluid mechanics and heat transfer problems
		C05	Develop shape functions for higher order elements and explain the concept of convergence and refinement.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Finite Element	C01	1		1									2	-	1
	C02	3	3	2	3	3								-	3
	C03	3	3	2	3	3								-	3

	C04	3	3	2	2	3							-	3
	C05	3	2	1	2	2							-	2
	Average	**2.6**	**2.75**	**1.6**	**2.5**	**2.75**						**2**	**--**	**2.4**

7ANU5 Automatic Control Systems

(3L+0T)

7ANU5	CONTENTS	HOURS
	Introduction: Open loop and closed loop control systems, series and parallel system; Feedback characteristics of control systems; Mathematical models of physical systems; Control systems and components. **Feedback Control System**: Transfer function of linear systems; Impulse response of linear Systems; Block diagrams of feedback control systems, reduction of block diagrams, signal flow graphs, output to input ratios. **Analysis of Feedback Control Systems**: Time response analysis, effects of derivative and integral control; Different types of test inputs; Steady state response of feedback control system, steady state error; Frequency response; Correlation between frequency domain and time domain specifications; Bode plot analysis. **System Stability:** Concept of stability and algebraic criteria; Routh-Hurwitz criterion; Root locus technique; Nyquist stability criterion. **TOTAL**	**40**
	TEXT BOOKS	
1	"Modern Control Engineering", K. Ogata, PHI learning	
2	"Automatic Control Systems", B,C. Kuo & F. Golnaraghi, Wiley	
	REFERENCE BOOKS	
S.NO.	**Name of author/Book/publisher**	
1	"Aircraft Flight Dynamics and Control", W. Durham, Wiley-Blackwell	

2	"Control System Design: An Introduction to State-Space Methods", B. Friedland, Dover Publications Inc.	
3	"Automatic Control of Aircraft and Missiles", J.H. Blackelock, John Wiley & Sons	
4	"Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems", B.L. Stevens, F.L. Lewis & E.N. Johnson, John Wiley & Sons	
5	"Advanced Control of Aircraft, Spacecraft and Rockets", Ashish Tewari, Wiley-Blackwell	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
7ANU5	**Automatic Control Systems**	**C01**	To classify the open, closed loop systems, various types of controllers and their application
		C02	To apply mathematical models for mechanical, hydraulic system to obtain transfer functions
		C03	To sketch block diagrams and signal flow graphs to obtain transfer functions
		C04	To Predict the stability of control system employing Nyquist, polar, bode and root locus plots as stability criteria
		C05	To analyze the different auto pilot and fly-by-wire control system

CO-PO MAPPING

Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12
C01	3	2	1	1		2				1		1
C02	2	3	1			1						1
C03	2	2	1	3		2					1	

C04	2	3	3		1						1	1
C05	2	3	1	3					2			
Average												

7ANU6.1: Non-Destructive Testing

(3L+0T)

7ANU6.1	CONTENTS	HOURS
	Introduction to NDT: Fundamentals of non-destructive testing and evaluation, physical characteristics of materials and their applications in NDT, advantages and limitations of NDT; Visual inspection techniques. **Liquid Penetrant Testing:** Basic principle; types and properties of liquid penetrants, methods of application; Developer application and inspection, interpretation of results. **Magnetic Particle Testing:** Basic theory of magnetism; Magnetization methods; Field indicators, particle application, inspection. **Eddy Current Testing:** Basic principle, Faraday's law, inductance, Lenz's law, self and mutual inductance, impedance plane; Generation of eddy currents, properties of eddy currents, eddy current sensing elements, inspection system and probes, eddy current instrumentation; System calibration; Applications and limitations. **Ultrasonic Testing:** Basics of ultrasonic waves; Ultrasonic equipment; Test method, variables affecting an ultrasound test; Distance and Area calibration; Weld inspection by UT. **Radiography:** X-rays and their properties; X-ray generation, absorption and atomic scattering; Image formation, image quality; Digital Radiography, neutron radiography; Image interpretation; Radiation Shielding; Radiography applications, limitations and safety. **Special Techniques:** Acoustic Emission testing; Holography; Thermography; Magnetic Resonance Imaging; In-situ metallography.	

	Industrial Applications of NDT: Span of NDT activities in railways, nuclear and chemical industries, aircraft and aerospace industries, automotive industries, offshore gas and petroleum projects, coal mining industry; NDT of pressure vessels, castings, welded constructions. **TOTAL**	**40**
	TEXT BOOK	
1	"Non-Destructive Testing", Louis Cartz, ASM International	
2	"Non-Destructive Test and Evaluation of Materials", J. Prasad & C.G.K. Nair, McGraw Hill Education	
	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	
1	Non-Destructive Testing Techniques", Ravi Prakash, New Age International Publishers	
2	"Introduction to Non-Destructive Testing: A Training Guide", P.E. Mix, Wiley	
3	"Aeronautical Applications of Non-Destructive Testing", Abbas Fahr, DEStech Publications	
4	"Practical Non-Destructive Testing", B. Raj, T. Jayakumar & M. Thavasimuthu, Narosa Publishing House 5. "Non-Destructive Testing", B. Hull & V. John, Springer-Verlag New York Inc.	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU6.1	**Unmanned Aerial Vehicles**	**CO1**	Enumerate different types of defects in metals and composites and describe techniques to locate surfacedefects..
		CO2	Apply radiographic technique to detect the defects.
		CO3	Illustrate the methodology of ultrasonic testing to evaluate size and location of defects.
		CO4	Interpret the presence of defects using magnetic particle inspection.
		CO5	Identify the crack using eddy current testing system and select a suitable NDT method for different applications.

CO-PO MAPPING

Unmanned Aerial Vehicles	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	2	3	1	3	1									
	C02	2	3	1	3	1									
	C03	2	3	1	3	1									
	C04	2	3	1	3	1									
	C05	2	3	1	3	1									
	Average	2	3	1	3	1									

7ANU7: Computational Fluid Dynamics Lab

(3L+0T)

6ANU7	CONTENTS	HOURS
	• Introduction to ANSYS Fluent, its features and different options • Generation of structured and unstructured mesh over simple objects • Boundary layer resolution and grid independence test • Flow over flat plate and use of transition models • Inviscid and viscous flow over circular cylinder at different Reynolds number • Laminar and turbulent flow in a pipe • Flow over airfoil at high Reynolds number and use of different turbulence models • Supersonic flow past wedge and cone • Transonic flow over subsonic and supercritical airfoils • Flow over finite wing and effect of aspect ratio and taper ratio Flow in nozzles and diffusers • Writing codes in C/ C++/ MATLAB for simple flow fields	

	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	
1	"ANSYS Fluent Tutorial Guide", Sylvain Serra	
2	"ANSYS FLUENT 14.0 Simulation Analysis and Design Optimization", S.B. Cheng & L.M.G. Bian, Machinery Industry Press	
3	"FLUENT Learning Modules", S. Weidner, Cornell University Confluence (https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules)	
4	"ANSYS Workbench 14.0 for Engineers and Designers", Sham Tickoo, Dreamtech Press	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU7	**Aerospace Propulsion Lab**	**C01**	Analyze Basic geometry and modeling approach using commercial software
		C02	Solve lid driven cavity, backward facing step and pipe flow problems
		C03	Solve two- and three-dimensional fluid flow and heat transfer analysis problems
		C04	Demonstrate the ability to evaluate and interpret CFD analysis results for design and evaluation purposes
		C05	

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Aerospace Propulsion	**C01**	3	3	2	2	3				2			2		
	C02	3	3	2	2	3				2			2		

	C03	2	3	2	2	3				2			2		
	C04	3	3	3	2	3				2			3		
	C05														
	Average	**3.0**	**3.0**	**2.0**	**2.0**	**3.0**				**2.0**			**2.3**		

7ANU8 Aircraft Design Lab

(3L+0T)

7ANU8	**Aircraft Design Lab**	**HOURS**
	• Conceptual design based on preliminary mission requirements • Survey of existing vehicular configurations (in similar category) • Lofting (preliminary layout sketches) • Preliminary weight estimation • Optimization of wing loading and thrust loading • Selection of engine • Selection of wing parameters • Selection of fuselage parameters and internal layout • Location of engines and landing gear • Design of tail areas and control surfaces • Revised three-view drawing • Estimation of weights of various components • Calculation of centre of gravity and its shift • Estimation of aerodynamic characteristics and performance evaluation • Estimation of spanwise load distributions on wing and tail • V-n diagram for the design study • Estimation of gust and manoeuvrability envelopes • Internal design of wing and fuselage considering buckling loads and margin of safety • Estimation of cost and airworthiness of airplane, trade-off studies **TOTAL**	**40**

	TEXT BOOK	
1	Aircraft Design: A Conceptual Approach", D.P. Raymer, AIAA Educational Series	

	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	
1	"Fundamentals of Aircraft Design", L.M. Nicolai, METS Inc.	
2	"Synthesis of Subsonic Airplane Design", E. Torenbeek, Springer	
3	"Aircraft Conceptual Design Synthesis", D. Howe, Wiley	
4	"Aircraft Design Projects: For Engineering Students", L.R. Jenkinson & J.F. Marchman, AIAA Education Series	
5	"Civil Jet Aircraft Design", L.R. Jenkinson, P. Simpkin & D. Rhodes, AIAA Education Series	

COURSE OUTCOME

Course code	Course Name	Course Outcome	Detail
7ANU8	**Aircraft Design Lab ab**	**C01**	Compare the different types of aircraft configurations based on mission requirements
		C02	Apply the primary design concept on aircraft design methods
		C03	Analyze the aircraft different component like wing, fuselage, engine, landing gear and control surfaces based on aircraft detail design knowledge
		C04	Determine the aircraft different components weight, aircraft center of gravity and performance parameter.
		CO5	Discuss the different load on aircraft components and trade-off studies

CO-PO MAPPING

Aircraft Design Lab	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P010	P011	P012
	C01	3	3	2	1		1	1				1	
	C02	2	1	2	3		1				1		1

	C03	2	3	2	1	1				1		1	
	C04	3	1	2	3					1			
	C05	3	1	1						1			1
	Average												

7ANU9 FEM Lab

(3L+0T)

7ANU9	**CONTENTS**	**HOURS**
	• Introduction of GUI of the software ANSYS • Analysis of trusses • Analysis of beams and frames (bending and torsion problems) • Plane stress and plane strain analysis problems • Problems leading to analysis of axisymmetric solids • Problems leading to analysis of three-dimensional solids • Heat transfer problems • Model analysis problems for natural frequency determination	

	TEXT BOOKS	
1	"Finite Element Analysis: Theory and Application with ANSYS", S. Moaveni, Pearson Education Limited	
2	"Engineering Analysis with ANSYS Workbench 18", G. Zhang, College House Enterprises	
	REFERENCE BOOKS	
S.NO.	**Name of author/Book/publisher**	
1	"Finite Element Modeling and Simulation with ANSYS Workbench", X. Chen & Y. Liu, CRC Press	
2	"Practical Aspects of Finite Element Simulation – A Student Guide", free ebook by Altair University	

3	"Working with ANSYS: A Tutorial Approach", D. Zindani, A.K. Roy & K. Kumar, I.K. International Publishing House Pvt. Ltd.	
4	"ANSYS Workbench 14.0 for Engineers and Designers", S. Tickoo, Dreamtech Press	
5	"Introduction to ANSYS 16.0", R.B. Choudary, I.K. International Publishing House Pvt. Ltd.	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
7ANU9	**FEM Lab**	**C01**	Analyze beams and frames using commercial FEM software
		C02	Analyze plane stress, plane strain and axisymmetric structural problems
		C03	Solve multi-dimensional heat transfer and modal analysis problems by FEA
		C04	Demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purposes
		C05	

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
FEM Lab	**C01**	3	3	2	2	3				3			2		
	C02	3	3	2	2	3				**2**			2		
	C03	3	3	2	2	3				**2**			2		
	C04	3	3	2	2	3				**2**			2		
	C05														
	Average	**3**	**3**	**2**	**2**	**3**				**2**			**2.3**		

7ANU10 Minor Project

(3L+0T)

7ANU 10	Minor Project	HOURS
	• The students are required to work in groups of not more than three students on a project related to Aerospace Engineering under the guidance of a faculty member in one of the labs in the college. • The project topic should be such that it enables them to bring into practice the theoretical concepts learnt as well as learn new concepts and has to be approved by Project Coordinator. • The students are required to meet their project guides at least once in a fortnight and maintain a record of the same in a project diary. • A feasible working strategy should be developed and presented within a month. • At least two mid-semester presentations should be organized by Project Coordinator to review the progress during the semester. • A technical report and presentation has to be submitted at the end of the semester for evaluation of the work. The Project Coordinator should preferably be one of the members of the external grading committee. **TOTAL**	**40**

COURSE OUTCOME

Course code	Course Name	Course Outcome	Detail
7ANU10	Minor Project	**C01**	Identify a real-life problem or industrial problem.
		C02	Collect and analysis possible solutions, examine technical and economic feasibility of the solution.
		C03	Design promising solution considering environment and sustainability.
		C04	Prepare DPR (Detailed Project Report) and present.
		CO5	Grasp the norms for performing in team.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Minor Project	**C01**	2	3			1	1	2	1	3	1	2	3		
	C02	2	3	3	1	1	1	2	1	3		2	3		
	C03	2	3	3	3	2	2	3	1	3		3	3		
	C04	2	2	1	1	1			1	2	3	2	3		
	C05								1	3	2	1	2		
	Average	**2**	**2.8**	**2.3**	**1.7**	**1.3**	**1.3**	**2.3**	**1**	**2.8**	**2**	**2**	**2.8**		

7ANU11 Practical Training

(3L+0T)

7ANU11	Practical Training	HOURS
	All the students are required to give a presentation on the concepts learnt during industrial training after 3rd year, and to submit a report in standard format covering their entire work during the period. **TOTAL**	**40**

COURSE OUTCOME

Course code	Course Name	Course Outcome	Detail
7ANU11	**Practical Training**	**C01**	Explore the recent technological development through visiting the industries
		C02	Discover the various theoretical aspects in real time industrial scenario

		C03	Simulate and practice the concept in real situations
		C04	Collect data and prepare reports on the experiments/field visit.
		CO5	

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Practical Training	**C01**	1	1				1	2		2			2		
	C02	2	2	1		2	2	1		2	2		3		
	C03	2	3	2	2	3	1	1	1	2	2		2		
	C04	2	2	1	3	3	1			2	2		2		
	C05														
	Average	**1.8**	**2**	**1.3**	**2.5**	**2.7**	**1.3**	**1.3**	**1**	**2**	**2.5**	**2**	**2.3**		

8ANU1: Avionics

8ANU1	Avionics	HOURS
	Introduction to Avionics: Basics of avionics, need of avionics in civil and military aircraft and space systems; Cockpit basics; Integrated avionics architecture, typical avionics system and subsystems. **Digital Avionics Bus Architecture:** Data buses MIL-STD-1553B, RS-232, RS-422, RS-485, AFDX, ARINC 664, ARINC 429, ARINC 629; Aircraft system interface. **Flight Deck and Display Systems**: Flight deck display technologies, CRT, LED, LCD, Touch screen, Head up display, Electronic instrumentation systems.	

	Audio and Communication Systems: Aircraft audio systems, basic audio transmitter and receiver principles, VHF communication system, UHF communication systems. **Ranging and Landing Systems**: VHF omnidirectional range, VOR receiver principles, distance maturity equipment, principles of operation; Instrument landing system, localizer and glide slope. **Position Inertial and Navigation System**: Satellite navigation systems, GPS principles, triangulation, position accuracy, applications in aviation; Principle of operation of INS, navigation over earth, components of inertial navigation systems, accelerometers, gyros and stabilized platform. **Surveillance System**: ATC surveillance systems, principles and operations; Standards; Collision avoidance system; Ground proximity warning system. **Auto Flight System:** Basic principles of auto pilot, longitudinal and lateral auto pilot; Automatic flight control system; Flyby-wire and fly-by-light technologies; Flight director systems; Flight management systems **TOTAL**	**40**
	TEXT BOOK	
1	"Introduction to Avionics Systems", R.P.G. Collinson, Springer	
2	"Introduction to Avionics", D.R. Cundy & R.S. Brown, Pearson	
	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	
1	Digital Avionics Handbook", C.R .Spitzer, U. Ferrel & T. Ferrel, CRC Press	
2	"Principles of Avionics", A. Helfrick, Avionics Communications Inc.	
3	"Principles of Modern Avionics", S. Nagabhushana & N. Prabhu, I.K. International Publishing House	
4	"Civil avionics system" & "Military Avionics Systems", I. Moir, A. Seabridge & M. Jukes, Wiley-Blackwell 5. "Avionics Fundamentals", Jeppensen, Aviall Services	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
6ANU1	Avionics	CO1	Demonstrate the working of simple digital circuits using logic gates.
		CO2	Create assembly language programs with microprocessor for simple applications.
		CO3	Demonstrate the integration of avionic systems with data buses.
		CO4	Explain the working of aircraft communication and navigation systems.
		CO5	Discuss the autopilot systems in aircraft.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Avionics	C01	S	-	-	-	S	-	-	-	-	-	-	-	M	-
	C02	-	-	W	-	M	-	-	-	-	-	-	-	M	-
	C03	M	-	-	-	M	-	-	-	-	-	-	-	W	-
	C04	M	-	-	-	-	-	-	-	-	-	-	-	W	-
	C05	-	-	-	-	W	-	-	-	-	-	-	-	-	M
	Average														

8ANU2: REFRIGERATION AND AIR-CONDITIONING

(3L+1T)

8ANU2	CONTENTS	HOURS
	Introduction: Brief history and need of refrigeration and air conditioning, methods of producing cooling, ton of refrigeration, coefficient of performance, types and application of refrigeration and air condensing systems. **Refrigerants:** Classification, nomenclature, desirable properties; Eco-friendly refrigerants and environmental issues of refrigeration & air conditioning industry. **Vapour Compression Refrigeration (VCR) Systems:** Simple vapour compression refrigeration systems; Analysis of VCR cycle considering degrees of subcooling and superheating, VCR cycle on P-V, T-s and P-h diagrams; Actual VCR cycle; Comparison of VC cycle with air refrigeration cycle. **Aircraft Refrigeration System:** Necessity of cooling the aeroplane; Reversed Carnot cycle and its limitation; Reversed Brayton cycle; Bell-Coleman cycle; Aircraft refrigeration systems; Working and analysis of simple, bootstrap, reduced ambient and regenerative air refrigeration systems. **Psychrometry and Air-conditioning Processes**: Properties of moist air: specific humidity, dew point temperature, degree of saturation, relative humidity, wet bulb temperature; Psychrometric chart; Psychrometry of air conditioning processes; Mixing process and other basic processes in conditioning of air. **Human Comfort**: Selection of inside design conditions; Thermal comfort, heat balance equation, factors affecting thermal comfort, effective temperature, comfort chart and factors governing effective temperature; Selection of outside design conditions. **Air-Conditioning Load Calculations:** Outside and inside design conditions, sources of heating load, sources of cooling load, heat transfer through structure, solar radiation, electrical applications, infiltration and ventilation, heat generation inside conditioned space. **Air Conditioning Systems and Duct Design:** Classifications, equipment selection; Air distribution system, all-air, all-water and air-water systems, single and central air conditioning systems; Duct systems design; Filters; Refrigerant piping; Temperature, pressure and humidity sensors; Actuators and safety controls, accessories.	

	TOTAL	**40**
	TEXT BOOK	
1	"Refrigeration & Air Conditioning", R.C. Jordan & G.B. Priester, Prentice Hall of India	
2	"Refrigeration & Air Conditioning", C.P. Arora, McGraw Hill Education	
	REFERENCE BOOK	
S.NO.	**Name of author/Book/publisher**	
1	"Refrigeration and Air Conditioning", W.F. Stoecker & J.W. Jones, McGraw Hill Education	
2	"Basic Refrigeration and Air Conditioning", P.N. Ananthanarayanan, McGraw Hill Education	
3	"Refrigeration and Air Conditioning", Manohar Prasad, New Age International Private Limited	
4	"Refrigeration and Air Conditioning", R.C. Arora, Prentice Hall India Learning Private Limited	
5	"Refrigeration and Airconditioning: High Side Design", Arvind Agrawal, New Academic Science Limited	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
8ANU2	**Refrigeration and Air-Conditioning**	**CO1**	Correlate the knowledge about the basic components of refrigeration system and calculate its coefficients of performance.
		CO2	Analyze performance of vapor compression refrigeration system.
		CO3	Acquire knowledge about different kinds of aircraft refrigeration systems.
		CO4	Understand and analyze the psychometric processes used in refrigeration and air-conditioning system.
		CO5	Compute cooling and heating loads in an air conditioning system.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Refrigeration and Air-Conditioning	**C01**	3	3	2			2	2					1	-	
	C02	3	3										2	-	
	C03	3	2	2	1		2	2				1	2	-	1
	C04	3	3	1	2								1	-	1
	C05	3	3	1	2								1	-	
	Average	**3**	**2.8**	**1.5**	**1.67**		**2**	**2**				**1**	**1.4**	**-**	**1**

8ANU3: Airport Management and Aircraft Maintenance

(3L+1T)

7ANU3	Airport Management and Aircraft Maintenance	HOURS
	Introduction: The evolution of aviation, growth drivers, issues and challenges; Global aviation industry, major players in aviation industry in India, SWOT analysis of the different airline companies in India, market potential and current challenges of airline industry in India **Aircraft Rules:** ICAO, international environmental protection policies; Airport Authority of India, DGCA, Airport Economic Regulatory Authority of India; Aircraft Act 1934, The Aircraft Rules 1937, Civil Aviation Requirements (CAR); Aircraft manuals, Aeronautical Information Circulars. **Airport Planning and Management:** Functions of airports; Airport layouts and configurations; Airport terminal planning; Various airport services; Effect of privatization; An overview of any international airport. **Air Traffic Control:** Principles of air navigation and air traffic control; Classification of ATS air spaces; Assignment of cruising levels; Air traffic zones and approach areas, methodology for slot allocation, aerodrome data; Airport & aircraft security, crisis management at airports.	

	Airworthiness: Knowledge of various mandatory documents issued to establish airworthiness of aircraft parts; Airworthiness requirement for gliders, micro light aircraft, ferry flight and hot air balloons; Load and trim sheet; Aircraft inspection, cockpit check list, preparation and use of concept and emergency check list, defect management; Various logbooks required to be maintained for aircraft and their purpose. **Maintenance of Aircraft Structural Components:** Types of maintenance schedules, damage investigation, nondestructive testing; Sheet metal repair and maintenance; Maintenance and repair of plastic components; Inspection and repair of composite components; Installation and maintenance of instruments; Inspection and maintenance of various aircraft systems such as power plant, landing gear system, air-conditioning and pressurization system, fuel & hydraulic system, position and warning system, auxiliary systems. **Licensing of Aircraft Maintenance Engineers:** Knowledge of privileges and responsibilities of the various categories of AME licence and approved persons; Duties of an aircraft maintenance engineer licence holder; Student flight engineer; Validation of foreign AME licence. **TOTAL**	**40**
	TEXT BOOKS	
1	"Airport Planning and Management", S.B. Young & A.T. Wells, McGraw-Hill Education	
2	"Aviation Maintenance Management", H.A. Kinnison & T. Siddiqui, McGraw Hill Education	
	REFERENCE BOOKS	
S.NO.	**Name of authors/Books/publishers**	
1	"Fundamentals of Aircraft Maintenance Management", H. Timothee, Notion Press	
2	"Airport Management", C.D. Prather, Aviation Supplies & Academics Inc.	
3	"Aircraft Maintenance and Repair", M. Kroes & R. Sterkenburg, McGraw Hill Education	
4	"Aviation Management: Global and National Perspectives", Ratandeep Singh, Kanishka Publishing House 5. "Air Transportation: A Management Perspective", J.G. Wensveen, Routledge	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
8ANU3	Airport Management and Aircraft Maintenance	**C01**	The students were able to understand about the Aviation's History, its major players and it current trends and challenges
		C02	It enables the student to do the Planning of the Airport and to perform operations involved in the Airport.
		C03	It enables the students to know about various logbooks used in airline industry
		C04	It enables the students to understand and adhere to the various Regulations involved Aviation Industry for licensing of aircraft maintenance engineers.
		C05	It enables the students to understand about the ATC control process, slot allocation and DGCA etc.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Airport Management and Aircraft Maintenance	**C01**	3	3	2	2			1		2			2		
	C02	3	3	2	2			1		2			1		
	C03	3	3	2	2					1			2		
	C04	3	3	2	2					2			1		
	C05	3	3	2	2					1			2		
	Average														

8ANU4.1 Missile Technology

(3L+0T)

ANU4.1	CONTENTS	HOURS
	Introduction: History of missiles, classification of missiles; Concept of guidance, peaceful application of guidance; Selection of materials for missiles. **Major Components of Missiles:** Airframe, flight control system, guidance subsystem, proximity fuse, warhead, propulsion system. **Missile Performance:** Aerodynamics characteristics of airframe components, forces and moments acting on a missile while passing through atmosphere, slender body aerodynamics, drag estimation; Equations of motion for three-dimensional motion through atmosphere and vacuum, one-dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields, description of vertical, inclined and gravity turn trajectories; Effect of earth's rotation, inertial and noninertial frames, coordinate transformation; Powered and unpowered flight, boost-glide trajectory, boost-sustain trajectory, long range cruise trajectory, long range ballistic trajectory, re-entry conditions; Brief description of fin-stabilized and spinstabilized missiles and their force systems; Manoeuvring flight: flat turns, pull-ups, relation between manoeuvrability & static stability margin; Multistaging of ballistic missiles, separation techniques. **Fundamentals of Guidance:** Different phases of missile; Homing guidance categories; Introduction to aerodynamic and jet control methods; Various types of aerodynamic control methods for tactical and short range missiles; Various types of thrust vector control methods; Interception and avoidance. **Rocket Propulsion:** Solid, liquid, hybrid rocket motor, single base propellants, double base propellants, composite propellants, CMBD propellants and their ingredients; Propellant grains and types of burns, erosive burning, pyrotechnic devices and systems, igniter & ignition system; Propellant mass fraction, thrust coefficient, characteristic velocity, burn rate, total impulse; Types of nozzles and thrust vector control.	
	TOTAL	**40**

	TEXT BOOKS	
1	"Missile Design and Systems Engineering", E.L. Fleeman, American Institute of Aeronautics & Astronautics	
2	"Missile Guidance and Control Systems", George M. Siouris, Springer	
	REFERENCE BOOKS	
S.NO.	**Name of author/Book/publisher**	
1	"Tactical and Strategic Missile Guidance", P. Zarchan, AIAA	
2	"Modern Missile Guidance", R. Yanushevsky, CRC Press	
3	"Automatic Control of Aircraft And Missiles", John H. Blacelock, Wiley	
4	"Missile Guidance and Pursuit: Kinematics, Dynamics and Control", N.A. Shneydor, Woodhead Publishing	
5	"Rocket Propulsion and Spaceflight Dynamics", J.W. Cornelisse, H.F.R. Schöyer & K.F. Wakker, Pitman Publishing Limited	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
8ANU4.1	**Missile Technology**	**C01**	The student will understand the basic concepts of missile aerodynamics.
		C02	The student will know about the different configurations of missiles and will be able to estimate the drag of missiles
		C03	The student will be able to design the missile body in order to optimize performance
		C04	The student will understand the significance of aerodynamics during the launching phase
		C05	The student will be able to design appropriate stabilizers and control surfaces to fulfill the stability and control requirements of the missile

CO-PO MAPPING

Missile Technology	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	S	M	M	W										
	C02	S	S	M	W	M								M	
	C03	S	S	M	M	M									
	C04	S	S	M	M	S								M	
	C05	S	M	M	W										
	Average														

8ANU5: Avionics Lab

(3L+0T)

8ANU5	CONTENTS	HOURS
	• Design and implementation of 4-bit adder and subtractor circuit using IC 7483 and IC 7486 • Implementation of multiplexer/demultiplexer circuits • Implementation of encoder/decoder circuits • Design and implementation of 4-bit shift register with D-flip flops using IC 7474 • Timer circuits, shift registers, binary comparator circuits • Addition and subtraction of 8-bit and 16-bit numbers • Sorting of data in ascending & descending order • Sum of a given series with and without carry • Multi-byte addition in BCD mode • Interface programming with 4-digit 7-segment display and switches and LEDs • 16 Channel Analog to Digital Converter & generation of ramp, square, triangular wave by Digital to Analog Converter • Use of data buses for message transfer • Remote Terminal Configuration of data bus	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
8ANU5	Avionics Lab	C01	Appreciate the use of microprocessors, data buses and avionics system architectures
		C02	Gain knowledge about various avionics subsystems
		C03	Understand the addition, subtraction concepts and storing data in microprocessor.
		C04	Design and analyze simple digital circuits
		C05	Carry out data transmission using data bus

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Avionics Lab	C01	3	2	2	2	3							2		
	C02	3	2	2	1	3							2		
	C03	3	3	3	3	3									
	C04	3	3	3	3	3									
	C05	3	2	2	2	3									
	Average														

8ANU6 Refrigeration and Air-Conditioning Lab

(3L+0T)

8ANU6	Refrigeration and Air-Conditioning Lab	HOURS
	• Study of different types of expansion devices and evaporators used in refrigeration system • Evaluation of coefficient of performance of cycle and tonnage capacity of refrigeration unit • Calculation of theoretical and actual value of coefficient of performance on vapour compression test rig	

	• Experiment on two-stage reciprocating compressor for determination of volumetric efficiency and effect of intercooling • Study of cut-sectional models of reciprocating, rotary and centrifugal compressor • Determination of coefficient of performance and refrigeration load of a chilling plant • Determination of coefficient of performance and tonnage capacity of a mechanical heat pump • Calculation of coefficient of performance of aqua-ammonia absorption system • Study of various controls used in refrigeration and air-conditioning system • Experiment on air-conditioning test rig & calculation of various performance parameters • Study of different psychrometric processes & charts • Study of working principle of air refrigeration system using charts • Visit of central air conditioning plant and cold storage and detailed study of their different components. **TOTAL**	**40**

COURSE OUTCOME

Course code	Course Name	Course Outcome	Detail
8ANU6	**Refrigeration and Air-Conditioning Lab**	**C01**	Correlate the knowledge about the basic components of refrigeration system and calculate its coefficients of performance.
		C02	Understand the thermodynamic cycle of two stage reciprocating compressors and compute the volumetric efficiency along with other types of compressors.
		C03	Acquire the knowledge about the performance and refrigeration load of a chilling plant, heat pump.
		C04	Study of various controls, psychometric processes used in refrigeration and air-conditioning system.

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
Refrigeration and Air-Conditioning Lab	**C01**	2	2	2									2		
	C02	3	2	2									2		
	C03	3	2	2									2		
	C04	3	2	2									2		
	Average	**3.0**	**2.0**	**2.0**									**2.0**		

8ANU7 Flight Simulation Lab

(3L+0T)

8ANU7	CONTENTS	HOURS
	• Demonstration of working of ILS and VOR using flight simulator • Demonstration of autopilot, ADF and other navigation instruments using flight simulator • Demonstration of an aircraft starting procedure with checklist using flight simulator • Determination of an aircraft performance parameters at various flying conditions using real-time flight simulator • Execution of a complete cycle of flight profile using real-time flight simulator • Demonstration of autopilot mode flight operation using flight simulator • Stability analysis using Root locus, Bode plot, Nyquist plot and Polar plot techniques • Design of lead, lag and lead-lag compensator for aircraft dynamics • Performance improvement of aircraft dynamics by pole placement technique • Design of displacement longitudinal and lateral autopilot • Design of automatic glide slope control system and flare control system • Analysis of actuation mechanisms of an aircraft and helicopter using Arduino with the help of Mission Planner software • Estimation of aerodynamics derivatives from wind tunnel tests • Assessment of dynamic signatures and impact on performance of abnormal flight conditions through simulation and tests using PC-based simulation and a 6-DOF motion-based flight simulator • Assessment and analysis of the dynamic effects of aircraft propulsion system failure Simulation of effect of deploying different control surfaces	

COURSE OUTCOME

Course Code	Course Name	Course Outcome	Detail
7ANU9	FEM Lab	C01	The student will realize the significance of an aircraft simulator
		C02	The student will know the basic flight operation procedures, instruments in an aircraft
		C03	The student will know how to start, takeoff and land the aircraft
		C04	The student will know to execute different maneuvers in the airplane
		C05	The student will have an understanding of the autopilot

CO-PO MAPPING

	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
FEM Lab	C01	S	S	S	S										
	C02	S	S	S	S										
	C03	S	S	S	S									M	
	C04	S	M	S	M	W									
	C05	S	S	M	S	M									
	Average														

8ANU8 Seminar

(3L+0T)

8ANU8	Seminar	HOURS
	• The purpose of this course is to introduce students to the field of technical research and formal documentation of research work in the form of research papers and technical reports. • Every student is required to select a seminar topic in emerging areas of science and technology broadly related to Aerospace Engineering different from those already covered in previous years, with the consent of Seminar Coordinator. • Each student will be allotted a faculty member to serve as Seminar Guide, under whose guidance the student is supposed to study and present the latest research work related to the topic. • The student should learn to study and summarize research works related to the topic, and identify the state-of-the-art on the chosen topic. • During the class timings, students will give interim presentations on their chosen topics in front of their section teachers. At least two presentations per student should be completed during the semester. • By the end of the semester, every student has to prepare a Seminar Report and a Seminar Presentation. The report should formally summarize the relevant research in the area and be divided into no less than 5 chapters encompassing at least 45 pages, and its formatting should be in accordance with the guidelines provided by Seminar Coordinator. The presentation should be for about 15 minutes and include important and interesting points related to the topic and be technically perfect with proper formatting and grammar. • For internal evaluation, 40 marks will be assigned by subject teacher allotted to the respective section based on the presentations given by the student during the semester, and 35 marks will be given by Seminar Guide according to his evaluation of efforts put by student. • The external grading would be done by a committee of external examiners chosen by Seminar Coordinator with the consent of Head of Department, on the basis of final report and presentation. **TOTAL**	**40**

COURSE OUTCOME

Seminar	Course Outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	PSO1	PSO2
	C01	1	3	1				1	1	3	1		1		
	C02	1	1							3	3		1		
	C03	1	1					1	1	3	3		2		
	C04	1	1			2				3	3		1		
	C05														
	Average	**1**	**1.5**	**1**		**2**		**1**	**1**	**3**	**2.5**		**1.8**		

Course code	Course Name	Course Outcome	Detail
8ANU8	**Seminar**	**C01**	Review of recent industrial developments and scientific innovations.
		C02	compile information from different sources in comprehensive manner
		C03	Prepare technical report
		C04	Present the identified development/innovations
		CO5	

8ANU9 Major Project

(3L+0T)

8ANU9	Major Project	HOURS
	The primary objective of this course is to develop in students the professional quality of synthesis employing technical knowledge obtained in the field of engineering & technology through a project work involving design and analysis augmented with creativity, innovation and ingenuity. • The students are required to form groups of two to four students for the project work. • Each group should work under the guidance of a faculty member who will serve as the project mentor. A feasible and interesting project objective related to aerospace engineering should be chosen taking approval from Project Coordinator. Each group should meet with its project mentor regularly and maintain the record of discussion in a project diary. • The Project Coordinator should call regular meetings of all groups to monitor their regular progress in their projects, and give constructive suggestions as required. • For internal grading, the Project Coordinator would assign marks out of 90 based on regular assessment throughout the semester during project review meetings, and the project mentor would give marks out of 60 to each student based on his perception of sincerity of each student. • Each group has to prepare a technical report according to the guidelines provided by Project Coordinator. The report should contain introduction to the topic, technical background, objective, working methodology, detailed calculations, data analysis, results, discussion and the final conclusion of project. The external evaluation would be done by external examiners allocated by HoD based on the final presentation, project demonstration and technical report. 30 marks may be allocated to the report, 30 marks to the presentation and 30 marks to the successful demonstration and realization of desired objectives **TOTAL**	**40**

COURSE OUTCOME

Course code	Course Name	Course Outcome	Detail

8ANU9	**Major Project**	**C01**	Arrange necessary resources and prepare project plans
		C02	Develop the required product/solution considering technical/financial viability
		C03	Test and validate the solutions based on experiment and field trials
		C04	Prepare project report and present results/solution.
		CO5	

CO-PO MAPPING

	Course Outcome	**P01**	**P02**	**P03**	**P04**	**P05**	**P06**	**P07**	**P08**	**P09**	**P10**	**P11**	**P12**	**PSO1**	**PSO2**
Major Project	**C01**	1					1	2	1	2	2	3	3		
	C02	2	2	3	1	2		1	1	3	2	2	3		
	C03	2	2	1	3	2		1	1	3	2	1	3		
	C04	2		1	1	1			1	2	3	1	3		
	C05														
	Average	**1.8**	**2**	**1.7**	**1.7**	**1.7**	**1**	**1.3**	**1**	**2.5**	**2.3**	**1.8**	**3**		